THE PALATABILITY AND NUTRIENT VALUE OF TALL FESCUE (FESTUCA ARUNDINACEA SCHREB.) FORAGE AND EVALUATION OF SEVEN SYSTEMS OF FORAGE FINISHING BEEF STEERS

by

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INTRODUCTION

Most cattlemen in the Southeast are in the cow-calf business and sell calves at weaning. The extra cost of shipping feeder calves for finishing and then shipping the carcasses back to the East adds to the price of meat. This practice also takes away a potential source of profit by farmers who could finish these calves. Economically, it is difficult for states in the East to compete with grain producing states for the production of slaughter cattle in the feedlot. The alternative of using forages native to the areas of the Appalachians with a minimum of high energy grains should increase the economic potential for producing market animals in this area.

Virginia and surrounding states have mild winters and reasonably long grazing seasons with a climate optimum for production of high quality forages. Generally, forages are the cheapest source of energy for ruminants. Cow-calf production cycles have been made to coincide with seasonal forage production. A major problem which has been encountered in finishing cattle on pasture is that they are ready for market at only one time during the year due to the seasonality of forage production. Numerous management practices have been evaluated for maximizing the production of slaughter steers on pasture including stockpiled forages, top grazing and grain supplementation.

Tall fescue is a cool season forage which grows well under a wide range of climatic conditions. Animals grazing tall fescue during the summer generally do not gain as rapidly as animals grazing other cool season forages. The innovative technique of accumulating tall fescue from August to November (stockpiling) for winter grazing appears to maxamize quality and quantity of fescue, while lengthening the grazing season. Fescue generally maintains its quality longer under severe winter conditions than other cool season forages. Stockpiling fescue holds great promise for increasing the production capacity of pasture.

Minimizing grazing pressure (top grazing) and supplementing grain on pasture can shorten the finishing period. Top grazing allows steers more selective grazing which generally results in consumption of forage higher in crude protein and nitrogen-free extract, and lower in fiber. Grain supplementation tends to shorten the fattening period while increasing the carrying capacity of land.

Growing compatible mixtures of grasses and legumes tends to maximize total dry matter and total digestible nutrient yield. Legumes are nitrogen fixers which increase available nitrogen in the soil, thereby decreasing nitrogen fertilization requirements of grasses.

The main objectives of the research reported herein were to critically evaluate seasonal chemical changes in forages and relate these changes to performance of cattle in different forage grazing systems for producing slaughter steers with minimum grain at four times during the year, and to evaluate the palatability and nutrient availability of tall fescue during the four seasons.

LITERATURE REVIEW

Forage production and utilization is being researched more intensely in an effort to produce high quality feedstuffs for ruminants. In 1970, forages comprised 55% of the energy consumed by all farm animals, expressed as total digestible nutrients (Reid, 1976). Campling (1964) reported that economic returns of grazing cattle are limited by restricted voluntary intake of energy from pasture, compared to grain. Cattle on pasture generally gain at a slower rate and require more feed per unit of gain than grain-fed animals (Dinius et al., 1975, and Oltjen et al., 1971).

Forages generally contain adequate digestible protein for animal production needs, but tend to be deficient in digestible energy content (Nowakowski, 1962). Wing (1960) reported that lactating dairy cows fed green chop alfalfa consumed enough digestible protein to sustain milk production at 30 kg per day. However, the energy content of alfalfa was only sufficient to produce 7 kg of milk per day.

Hay and silage making are widely used methods of preserving forage but considering the added expense and field losses, the cost per unit of starch equivalent by either method is 50% above that of fresh forage grazed by livestock (Hamilton, 1955). These figures appear to be high, but losses in quality and quantity occur in both processes. Limiting expenses for harvesting, storing, handling and labor is imperative for economical forage feeding of beef cattle (Van Keuren, 1970). At times hay and silage making are necessary due to the seasonality of forage production.

The value of forage produced in the United States has been estimated recently to exceed 10 billion dollars (Spague, 1974). Much of the land in this country is best suited for forage production, frequently making grazing by ruminants the most profitable method of harvesting and utilizing these energy sources. Ruminants are able to consume large quantities of fibrous materials and use them as energy sources through the action of the anaerobic microbial population in the rumen. The longer retention time in the digestive tract of high fiber feeds restricts total energy intake by the ruminant (Maynard and Loosli, 1969).

Measures of Forage Quality

The value of any forage source must be ultimately based upon the ability of livestock to consume and utilize it for production purposes (Mott, 1959). One method of standardizing forage quality based on both intake and quality is the "Nutritive Value Index" derived by Crampton *et al*. (1960). The general formula for this index is:

100 x daily forage intake (g) ÷ 80 x metabolic size (kg) x percent digestibility

This analysis is time consuming, expensive and subject to error because classes of livestock respond differently. They simplified this method by replacing *in vivo* digestibility with *in vitro* cellulose digestibility. The *in vitro* method of determining dry matter digestibility evaluates forage quality without the expense and time required for detailed *in vivo* data (Mott and Moore, 1970). *In vitro* data are becoming more widely accepted and are sometimes considered better than *in vivo* data because they are less expensive and time consuming to obtain, require smaller samples, and the procedure is not affected by such variables as animal age, status, health, production or level of intake (Tilley and Terry, 1963). Nelson et al. (1976) compared in vitro data obtained with different fermentation times to in vivo data, and found that a 48 hr incubation period minimized variation between run and forage. An equation was developed from this study (digestible dry matter = 5.2 + .7287 x, where x = in vitro value) to extrapolate in vitro data to in vivo observations. The in vitro technique does not always produce data equal to data from live animal studies, but the two methods generally rank forages similarly (Neher, 1976).

Many laboratory techniques for evaluating forage quality are time consuming which limit the number of samples which can be analyzed. One of the newest and most rapid methods developed for evaluating forages is infrared reflectance spectroscopy. Norris et al. (1976) reported high correlation coefficients (r = .80 to .99) using up to nine wavelengths to predict various indexes of forage nutrient value. This method appears to have potential for estimating forage quality under farm-type situations, but is probably not accurate enough for research. The method requires standards of known composition which are closely related to the sample being analyzed concerning climate and stage of growth. Peaks on the infrared reflectance spectrometer from the sample and standard are compared, and nutrient composition evaluated. The chemical component each peak on the spectograph is not known, which is a major limitation to the use of the instrument as a research tool.

A critical shortcoming of evaluating dry feeds and especially fresh forages is obtaining samples representative of ingested forage (Crampton and Harris, 1969). Reid and Jung (1965a) and Reid et al. (1976) reported dry matter digestibility and voluntary intake to be greater for grazing animals, using chromic oxide as a tracer, as compared to herbage samples obtained in the same location the animals were grazing. This demonstrates the selectivity of ruminants for portions of the plant high in nutrient value and palatability. Some of the variation between treatments in this study could be due to the indicator used, chromic oxide. None of the indicators presently available to forage researchers have proven to be completely satisfactory. Passage rates different than that of the feed being evaluated and losses of the marker through the digestive tract lead to artifacts.

Sampling plots or strips before and after grazing causes an underestimation of the amount of forage consumed by the animal due to continued regrowth of the plant (Cowlishaw and Adler, 1960). This underestimate will be more severe in times of accelerated forage production when cattle remain in paddocks for long periods of time, and would be minimal using stockpiled pastures for grazing in winter when forage is in a dormant state.

Chemical Composition, Digestibility and Palatability

Cell Wall Contents. The principle reason for evaluating chemical composition of forages is to estimate the digestibility and palatability of the plant. Van Soest (1965) found the chemical composition evaluated in the laboratory is more closely related to digestibility of the plant than to dry matter intake. In more mature plants with high cell wall contents increasing the cell wall content decreases both digestibility and voluntary intake. Percent cell wall content is an important value representing the fibrous, less digestible portion of the plant with the remainder of the plant being the highly digestible, readily available nutrients. In young fescue with low cell wall content levels, intake and digestibility are not closely related. Van Soest suggested that a cell wall content above 50 to 60% inhibits intake due to the large fiber mass of the older forages. Legumes typically have values below 50% which suggests that cell wall contents does not restrict intake in legumes. This could be a primary factor causing animals grazing legumes managed correctly to gain at a faster rate than animals grazing grass pastures.

Lignin and Silica. Increasing fiber levels in forages is generally accompanied by an increase in lignin levels. Relative lignin levels are variable between grass species with tall fescue ranked as containing medium levels, orchardgrass medium to high and bluegrass as containing high lignin levels (Sullivan et al., 1956). Sosulski et al. (1960) found lignin levels for orchardgrass to be 5.3, 7.8 and 8.9% for leaves, stems and seed heads, respectively. Rate of lignification was most rapid from preheading to heading.

Lignin decreases dry matter digestibility but does not appear to consistently affect voluntary intake of forages (Van Soest, 1965b). Voluntary intakes of both tall fescue and bluegrass increased with increasing maturity and lignin levels while intakes of orchardgrass decreased with high lignin contents in the forage.

Lignin has been considered an essentially indigestible portion of the plant which adds rigidity to the plant while protecting the carbohydrate portion of plants from microbial degradation (Van Soest, 1976). Weiss et al. (1978) and Guardiola et al. (1978) in Missouri and Illinois, respectively, reported lignin digestibilities of 30 to 40% for first cut fescue hay. The inconsistencies in lignin digestibility figures could be due to artifacts in the procedure for determining lignin.

Bailey (1976) found silica to be virtually indigestible when fed to cattle as a component of grass hay. Silica dilutes the energy content of the plant. Van Soest and Jones (1968) found that for each percentage unit increase in silica there was a three percentage unit decrease in digestiblity. These workers postulated that silica acts similarly to lignin; it may be associated with lignin where it encrusts cell wall carbohydrates, thereby lowering their availability. If the effects of silica were simply energy dilution, one would expect a 1:1 exchange for silica and dry matter digestibility instead of the observed 3:1 ratio. Silica or lignin levels divided by either cell wall content or acid detergent fiber were the combination of factors most closely related to cell wall content digestibility (Archer and Decker, 1977a).

Rumen Fill. Balch (1950) reported increasing dry matter digestibility increased rumen turnover time. Decreasing passage rate was associated with a higher quantity of fiber digestion. Breakdown of the fiber was greatest when ruminal contents were more liquid.

Blaxter et al. (1950) stated the amount of dry matter intake increased with increasing energy concentration in the feed. Blaxter et al. (1961) more accurately quantified the relationship of voluntary intake to the dry matter digestibility of feeds. Crossbred wethers, a minimum of 2½ years of age, were placed on trials which lasted 24 to 32 days. Dry matter intakes stabilized after 12 to 15 days, based on a metabolic weight basis. Voluntary intake of wethers increased rapidly as dry matter digestiblity increased from 38 to 70%. Intake stabilized as feeds increased above 70% digestibility with concentrate feeding decreasing intake. Poorer quality hays were retained longer in the gut. Increasing feed digestibility by 10 percentage units increased rate of gain 100% when feed digestibilities ranged from 40 to 60%.

Corbett et al. (1963) reported digestible organic matter intake decreased 20% as the organic matter digestibility of the forage decreased from 80 to 68%. Cattle were grazing orchardgrass-ryegrass pastures during the early spring. Campling (1964) found forage low in digestibility and high in fiber decreased rumen turnover time and voluntary intake.

Bailey and Forbes (1974) reported digestibility was positively correlated to voluntary intake of most forage, but varied among forage species. Reid et al. (1978) reported a correlation of .39 between voluntary intake and dry matter digestibility of bromegrass, orchardgrass, ryegrass and fescue forage.

Predicting Digestibility. The best predictors for in vivo dry matter digestibility and nitrogen digestibility were acid detergent fiber, R^2 = .86 and acid detergent fiber insoluble nitrogen, R^2 = .88

(Yu and Thomas, 1976). Acid detergent fiber insoluble nitrogen as a percent of the total nitrogen was negatively related to nitrogen digestibility to a greater extent in alfalfa hay samples with little or no heat damage, compared to those with severe heat damage. The accuracy of estimating organic matter digestibility based on several proximate components was variable between species, stages of growth and maturity of the plant (Kivimae, 1960). This was due to inherent differences in levels of crude protein, crude fiber and lignin between species as well as effects of maturity on lignin concentration and encrustation. *In vitro* dry matter digestibility (IVDMD) is not a good indicator of voluntary intake of fescue while it is for canarygrass (Bryan *et al*., 1970). IVDMD was lower than the actual dry matter digestibility for grazing animals, indicating selectivity by the animals as a major factor in underestimating forage quality. Van Soest (1965a) presented an equation for determining dry matter digestibility which included levels of cell solubles and lignin. Lignin content showed a positive relation ship with acid detergent fiber levels. Barton *et al*. (1976) found acid detergent fiber of tropical grasses to be more digestible than the acid detergent fiber temperate grasses. Hemicellulose, which has been implicated as an anti-palatability factor, was 30 to 35% in tropical grasses *vs*. 22 to 27% for temperate grasses. Crude protein content was a good indicator for IVDMD in tropical grasses (R^2 = .90) but not for temperate grasses (R^2 = -.15).

Climate. Minson *et al*. (1960) examined several forages in the United Kingdom and found digestibilities were higher in November than

July. Deinum et al. (1968), exploring a possible explanation for this, compared temperature and daylength on various fiber components. Increasing length of light per day in greenhouse studies increased cell wall content and decreased IVDMD ten percentage units from early to late spring. Increasing temperature decreased IVDMD while increasing lignin levels in the plant. Again, length of summer day and high temperatures of that season decreased forage quality.

Wilson et al. (1976) found that higher ambient temperatures with constant humidity increased cell wall contents while decreasing IVDMD of newly expanded leaves from both temperate and tropical grasses. As these leaves aged, the detrimental effect of high temperature on IVDMD remained but was not accompanied by an increased cell wall content. Lignin increased with higher temperatures, however, which could explain the continued decline in IVDMD. An ambient temperature of 18 C promoted a greater dry matter yield and increased root growth compared to 27 C. Total nonstructural carbohydrate levels were higher for plants that were grown at 27 C, compared to 18 C, demonstrating a lower rate of utilization or increased rate of synthesis of total nonstructural carbohydrates at the higher temperature.

High temperatures increased acid detergent fiber, lignin and percent leaves in alfalfa, but decreased IVDMD and total dry matter yield without altering crude protein (Vough and Marten, 1971). Bowman and Law (1964) found leaf percentage increased while lignin and cellulose decreased in orchardgrass with increasing temperatures from 17 to 22 to 27 C.

Increasing temperature and sunlight tends to accelerate maturity in the plant which decreases availability of nutrient components. Smith (1969) compared warm (32 C/24 C) and cool (18 C/10 C) day/night temperature regimes in growth chambers with 14 hr of light. The alfalfa was harvested at first bloom, 21 and 37 days for warm and cool temperatures, respectively. Herbage raised under cooler temperatures was higher in IVDMD, total nonstructural carbohydrates and lower in ash. All nutrients were higher in the leaf than in the stem except ash, total nonstructural carbohydrates and fiber. Stage of maturity between treatments was similar, but age of plants was vastly different.

Forage produced under 18.5 C/10 C, compared to 29.5 C/21 C temperature regimes, had a greater dry matter yield. Nitrogen fertilization tended to increase relative amounts of stems under both temperature regimes. Increasing temperature tended to decrease total nonstructural carbohydrate levels and high nitrogen fertilization in timothy grass under summer-like conditions (Smith and Jerviss, 1966). In another greenhouse study, Allison (1971) found increasing temperature and photoperiod decreased IVDMD and *in vitro* cellulose digestibility. Further, acid detergent fiber increased with light intensity and daylength while hemicellulose increased with increasing daylength and temperature. The deleterious effects in the summer of temperature, daylength, and light intensity on summer pastures are quite evident.

Total Nonstructural Carbohydrates.

Smith (1977) used tall fescue in greenhouse studies to compare day/night temperatures of 30 C/20 C. Cooler temperatures increased dry matter production 17%, IVDMD seven percentage units, total nonstructural carbohydrates 39 percentage units and culm total nonstructural carbohydrates 27 percentage units. The total nonstructural carbohydrates of cool season grasses are comprised mainly of fructose, glucose and sucrose. The storage of carbohdyrates in that study tended to occur when temperature conditions increased forage production. These carbohydrate reserves are used by the plant as an energy reserve for metabolic purposes as needed. The effect of cool temperature conditions on total nonstructural carbohydrate levels was first shown by Brown et al. (1963) in Virginia. Stockpiling tall fescue beginning August 14 resulted in increasing total nonstructural carbohydrates from 10.5% at 2 weeks to 29.2% at 11 weeks. Due to the increased total nonstructural carbohydrates and nitrogen-free extract of the plant, using stockpiled fescue as a major energy source for grazing animals in the winter was suggested. The production of this high quality forage in the late fall and winter would decrease winter hay feeding and possibly replace the hay with a higher quality feed.

Bland and Dent (1962) conducted experiments using orchardgrass varieties and found an apparent positive correlation between palatability and total nonstructural carbohydrate levels. A negative correlation between palatability and fiber levels was reported, except in July. Hemicellulose, a fiber component, has been shown to be a major component negatively related to palatability (Van Soest, 1976). Total nonstructural carbohydrate could have increased palatability by simply decreasing the relative percentage of hemicellulose or other anti-palatability factors.

Fertilization. Liberal fertilization of tall fescue for fall accumulation with potassium was advocated by Beard (1973) since this cation has been found essential in sugar metabolism of plants. Potassium is required for the formation of sugars and starches by plants and translocating soluble carbohydrates within the plant (Woodhouse and Griffith, 1976). Rhode Island researchers fertilized tall fescue plots with varying levels and found potassium had no effect on freeze tolerance (Cook and Duff, 1976). The total nonstructural carbohydrate level of control herbage was relatively high, suggesting potassium was not limiting in the soils initially. Balasko (1977) in West Virginia found that potassium fertilization increased total nonstructural carbohydrate levels of stockpiled fescue slightly, though not significantly. IVDMD levels were significantly higher for forage which had been fertilized, He further reported that fertilization with nitrogen significantly increased percent total nonstructural carbohydrates and total yield. Possibly, the requirement of potassium for stockpiling is greater under heavy nitrogen fertilization and potassium may aid in maintaining plants. Total dry matter yields during the 3 years of the study decreased 10% from December to January due to plants becoming senesced. Dry matter losses tended to be slightly higher for nitrogen fertilized pastures, probably because of their higher content of readily available nutrients which would be lost more readily during winter burn.

Summer total nonstructural carbohydrates levels tended to decrease with increasing nitrogen fertilization which was the opposite effect of nitrogen fertilization during the winter (Waite and Boyd, 1953). Waite

(1957) also reported increased nitrogen fertilization accompanied by heavy stocking rate further decreased total nonstructural carbohydrate levels while increasing crude protein content of the plant. Jones et al. (1961) found fertilization with 90 kg of nitrogen per hectare increased total dry matter yields, but decreased total nonstructural carbohydrate levels in April, July and September. Percent crude protein in the forage was increased by nitrogen fertilization. Phillipson (1970) reported nitrogen fertilization increased crude protein and non-protein nitrogen content of the plant. These non-protein nitrogen sources comprised up to one-third of the total protein component.

Variations in Total Nonstructural Carbohydrates. Fertilization with nitrogen generally increases crude protein content of the forage, many times by increasing nitrate levels, but decreases soluble carbohydrate level. Reid et al. (1966) fertilized pastures at rates of 0, 56, 112, 228, and 448 kg nitrogen per hectare. Crude protein increased 75% while soluble carbohydrate levels decreased from 10 to 4.5%. No differences were found between cell wall contents and acid detergent fiber levels between various nitrogen treatments. Increasing nitrogen fertilization increased apparent crude protein digestibility, possibly due to the increased dietary nitrogen presented to the gut with a decreasing percent of nitrogen in the feces from metabolic endogenous sources. However, dry matter and cellulose digestibilities were not changed, and voluntary intake decreased with increasing nitrogen fertilization rate. They suggested that intake was lowered due to a decrease in total non-structural carbohydrate levels.

Because total nonstructural carbohydrates are readily available as energy sources, fermentation may occur rapidly after the plant is harvested due to microbial attack (Noller, 1976). Total nonstructural carbohydrate levels also undergo dramatic diurnal variations. Glucose and fructose levels were much higher at 6 p.m. than at 6 a.m. (Lechtenberg et al., 1971). Stem total nonstructural carbohydrate levels were fairly constant at 4 to 5% while leaves increased from 10.2% in the morning to 20.3% in late afternoon. IVDMD increased 1.6 percentage units with this increase in total nonstructural carbohydrates. This clearly indicates that samples should be harvested on a uniform time schedule to minimize variation.

Smith (1973) compared the effect of different methods of drying samples on total nonstructural carbohydrate content and found freeze drying yielded the highest values (10%). Samples dried at various temperatures in drying ovens contained 8% (100 C), 7.4% (70 C) and 6.4% (60 C) total nonstructural carbohydrates. Similar results were obtained by Prestes et al. (1965), comparing 60 C and 80 C (3.9 vs. 4.2% total nonstructural carbohydrates, respectively). While drying at low temperatures tends to reduce total nonstructural carbohydrate content and alter IVDMD slightly, drying above 60 C has been shown to affect other chemical components, primarily due to the Maillard reaction. Artifact lignin, an artifical indigestible polymeric association between proteins and amino acids (particularly lysine) and degradation products of sugars with the lignin portion of the plant, may be caused by heating moist feeds and forages above 60 C (Van Soest, 1976). This would increase the calculated lignin content of the plant with the artifact nitrogenous products accounting for about 11% of the total lignin.

Forage-Animal Interrelationship

Soil nitrogen supply is the major limitation in grass production since most soils contain insufficient available nitrogen for high quality and dry matter yields from pastures (Rhykerd and Noller, 1976). Yiakoumettis and Holmes (1972) reported individual daily gains of young growing beef steers were similar whether animals grazed pastures receiving 50 to 300 kg of nitrogen per hectare. Carrying capacity was greatly increased as were kilograms of beef per hectare from higher nitrogen fertilization. Mahoney and Poulton (1962) found that fertilizing at 45 to 134 kg per hectare had no effect on digestible energy content of the forage or its nutritive value index. As fertilizer nitrogen costs increase, alternate methods of maintaining adequate available nitrogen for grass production must be investigated. A most practical method of supplying nitrogen to the soil is planting legumes in with existing grass swards. Legumes are nitrogen fixers and produce the equivalent of 50 to 200 kg of nitrogen per hectare per year (McCormick, 1977).

The method most commonly used for maximizing total dry matter and crude protein content of the herbage under practical situations is nitrogen fertilization. Mott et al. (1971) applied nitrogen at 0, 84 and 168 kg per hectare with one-half the steers receiving grain supplement at 1% bodyweight. Increasing nitrogen fertilization decreased rate of gain slightly, but doubled carrying capacity and kilograms of beef per hectare. This trial was conducted over a 4 year period with the possibility of volunteer clover in pastures receiving low nitrogen levels. The presence of legumes in the grass swards could account for the slightly increased individual gains of animals on pastures receiving low levels of nitrogen fertilizer. Cattle receiving grain at 1% of their body-weight demonstrated increased average daily gains and a higher carrying capacity per hectare.

Cattle consume mixtures of grasses and legumes more readily than pure stands of either herbage (Cowlishaw and Adler, 1960). Chan and MacKenzie (1971) have shown fertilizing an alfalfa-orchardgrass sward with nitrogen decreased legume levels in the sward. Nitrogen fertilization stimulates grass growth to a greater extent than legumes resulting in encrouchment and domination in the sward by grass. Fertilization of grass-legume swards with a minimum of 108 kg of nitrogen per hectare after defoliation of the fescue-white clover pastures increased dry matter yields. White clover populations were severly depressed at nitrogen levels of 108 kg per hectare and above. There was a decreased nutritive value index with higher nitrogen levels, indicating the loss of clover in the sward reduces pasture quality (Frame, 1973). Legumes tend to have a higher ratio of leaves to stems, a higher digestible nutrient value and a faster rate of passage than do grasses (Metcalfe, 1976). The inclusion of legumes in grass swards increases quality of pastures and yield unless heavily fertilized with nitrogen.

Holmes and Lang (1963) reported grass-legume pastures were generally higher in percent dry matter than were grass pastures heavily fertilized with nitrogen and also hypothesized the higher dry matter content may increase voluntary intake. Further research in this area showed no effects on voluntary intake on such small variations in dry matter content.

Rayburn (1977) compared the digestibility of pure stands of tall fescue and legumes and fescue-legume mixtures. He found consistent nonsignificantly higher digestibilities of grass-legume mixtures, compared to the means of the pure herbage sources, indicating a possible biological interaction due to growing grasses and legumes in combination.

Blaser et al. (1960) compared mixtures of orchardgrass, bluegrass or tall fescue with white clover or orchardgrass and tall fescue swards fertilized with nitrogen. Daily gains of grazing steers were 1.3, 1.2 and 1.3 kg for orchardgrass-ladino clover, fescue-ladino clover and bluegrass-white clover, respectively, compared to 1.0 and .9 kg for nitrogen fertilized orchardgrass and tall fescue, respectively. Blaser et al. (1956) found herbage quality to be similar between mixtures of fescue, orchardgrass or bluegrass with ladino clover and orchardgrass-lespedeza-ladino clover. Fescue-ladino clover pastures produced the lowest gains of any grass-legume pasture system. Orchardgrass pastures produced higher cattle gains than fescue grown in either pure stands and fertilized with nitrogen or grown with legumes. Nitrogen fertilized tall fescue and orchardgrass pastures had higher carrying capacity per hectare than any grass-legume mixture. Carrying capacity was higher for the fescue than orchardgrass pastures. This indicates greater yields on pastures with nitrogen fertilization, but could also demonstrate a lowered voluntary intake due to the absence of legumes in the pasture or a combination of the two effects. Individual daily gains were highest for animals consuming grass-legume mixtures but beef produced per hectare was maximized with nitrogen fertilized pastures.

Dinius et al. (1978) compared finishing beef steers fed ad lib diets of either orchardgrass or alfalfa hay. Steers fed the legume hay gained 1.1 kg per day, compared to .6 kg per day for steers fed orchard-grass hay plus a soybean meal supplement. The shorter retention time in the rumen or unidentified hormonal factors in legumes may explain these results (Church, 1975). Finishing animals have more critical energy requirements due to a lowered feed efficiency compared to growing animals. These results of Dinius et al. (1978) are possibly somewhat greater than would be expected under less intense circumstances.

Milk production of dairy cows fed grass-legume hay, grass-legume silage or a combination of the two were not different (Holter et al., 1976). Donker et al. (1976) reported daily gains for sheep fed alfalfa were 97 and 63 g per day and gains for reed canarygrass were 48 and -7 g per day for hay and fresh-cut forage, respectively. Voluntary intake and feed efficiency were higher for hay. The possibility of subclinical bloat symptoms may have restricted fresh alfalfa hay intake while fresh reed canarygrass contained 69% more alkaloids than dried forage. Alkaloids are reported to decrease palatability and to be higher in fresh, immature herbage (Gentry et al., 1968).

Maximizing forage quality generally minimizes dry matter yield. Meyer et al. (1957) evaluated stage of maturity in oat hay and found crude protein decreased from 24 to 11% with advancing maturity. Lignin levels increased from 2.5 to 6.2% and hemicellulose from 34 to 52% with increasing plant maturity. As quality of the oat hay decreased, dry matter yields were substantially increased. A method of maximizing pasture output is expressing the total kilograms of total digestible nutrients or digestible dry matter harvested per hectare. Blaser (1964) concluded that increasing leaf percent is typically associated with increased nutritive value of the forage. Plant maturity is generally accompanied by a lowered leaf percentage and nutritive value, but higher dry matter yields.

Rotation Grazing. Individual cattle weight gain tend to be maximized when pastures are kept in an immature stage of growth (Blaser et al., 1976). Generally, kilograms of beef produced per hectare are minimized due to the low pasture yields under these circumstances. A 120 day grazing trial with weanling Hereford calves given access to equal areas of tall fescue with 0, 2, or 4 subdivisions was conducted (Varthar et al., 1977). Rotationally grazing plots with four sub-divisions had 1000 kg more forage dry matter per hectare over the entire season but the herbage was slightly lower in IVDMD. The authors suggested IVDMD was lowered due to the inclusion of trampled herbage in the yield samples taken. It appeared that using four divisions would have provided more selective grazing due to the higher dry matter yields.

Stockpiling Forage. A recent innovative technique for managing fescue to increase yield and quality is stockpiling the forage. The basic definition of stockpiling or autumn-saving forages is allowing the forage to accumulate until late fall for winter grazing. Dates to begin stockpiling were evaluated in England by Corbett (1957). Yields were higher if stockpiling was begun in mid-July than in early September, but quality of the forage was lower. Forage waste due to winter burn occurred in three forages evaluated from November to mid-winter and was estimated to be 15% for orchardgrass, 20% for timothy, and 40% for ryegrass. Researchers in Scotland reported the best time to initiate stockpiling of orchardgrass was early August (Gardner and Hunt, 1955). In order to maximize forage utilization, they further suggested grazing of the stockpiled pastures should be completed by early January. This method maximizes forage quality and yield and allows for an earlier regrowth of the plants in spring.

The possible role of total nonsturctural carbohydrates in preserving forage quality during the winter is quite interesting. The total non-structural carbohydrates content of the leaf is not as complex as that in the stem during cold temperatures (Couchman, 1960). Olien (1967) suggested the formation of carbohydrate polymers from the total non-structural carbohydrates component in the cell depresses ice formation within the cell and thereby protects the plant to a greater extent during the winter. It would appear that any factor which increases total nonstructural carbohydrate levels during fall accumulation could potentially decrease winter burn. Winter burn is caused by freezing and thawing during the winter resulting in a leaching-out of cell solubles causing the plant to turn brownish and become lower in nutrient value. Fructosans are the total nonstructural carbohydrates component most adversly affected by decreasing ambient temperatures (Eagles, 1967).

Maryland researchers (Archer and Decker, 1977a) compared stockpiling tall fescue and orchardgrass with 0, 50 and 100 kg of nitrogen per hectare. Average yields were 4000 and 3300 kg of dry matter per hectare for tall fescue and orchardgrass, respectively, with tall fescue yielding higher quantities of dry matter regardless of fertilization rate. The digestible organic matter per hectare for orchardgrass was only 75% that of fescue. They further reported fescue grew better at both low and high soil temperatures than orchardgrass. Archer and Decker (1977b) reported that IVDMD decreased 3.4 percentage units in the fall for each 10 percentage unit increase in dead leaf material caused by "winter burn". Cell wall contents, lignin and silica levels were increased in the dead plant material as compared to green leaves, but nitrogen content remained fairly constant.

Baker et al. (1965) reported fescue appeared to be preferred for grazing over orchardgrass in early spring, autumn and winter. These workers in Great Britian suggested these results could be partially explained because fescue grew earlier in the spring and had a quicker recovery after defoliation than orchardgrass. They also reported yields for the two stockpiled forages were not significantly different but orchardgrass contained more dead material due to winter burn than fescue. Voluntary dry matter intake and digestible dry matter intake were higher for cattle which were gaining .8 kg per day, compared to cattle consuming orchardgrass and gaining only .4 kg per day. Orchardgrass, although apparently not as good for stockpiling as fescue, is a higher quality forage for winter grazing than either ryegrass or timothy (Baker et al., 1961). Taylor and Templeton (1976), in Kentucky, compared bluegrass and tall fescue for stockpiling and fertilizing with 0, 50 and 100 kg of nitrogen per hectare. Dry matter yields averaged 78% higher for fescue over a 3 year period, with yields of both forages decreasing during the winter due to plants becoming senesced. October total nonstructural carbohydrate levels were 11% for the two forages, but the level in fescue increased to 13% in Novmeber while that in bluegrass remained the same. This indicates fescue has a longer growing season and is more tolerant to cool temperatures.

Research in Virginia conducted by W. Sheehan et. al. (unpublished data, 1978) compared quality of tall fescue, orchardgrass and red clover. The red clover was very immature and weedy for a stockpiled forage, and sampling of the forage terminated after November 17 because of severe frost damage. The in vitro digestibility, total nonstructural carbohydrates and crude protein of red clover decreased 7.6, 7.0 and 2.1 percentage units, respectively, from November 1 to 17. Fescue samples were higher in total nonstructural carbohydrates, slightly higher in IVDMD and lower in acid detergent fiber and crude protein content, compared to orchardgrass from September 1 to November 17. Fescue sampled at mid-December was higher in IVDMD (65.4 vs. 59.7%), and lower in acid detergent fiber (36.6 vs. 41.7%), compared to orchardgrass. Mid-March samplings demonstrated both forages had deteriorated to an IVDMD of 48%, and total nonstructural carbohydrates and crude protein contents were below 4 and 11%, respectively.

Summer Management of Fescue

Another method of managing tall fescue for maximizing utilization is to round bale the forage for hay in the early head stage (Kroth et al., 1977). Crude protein and IVDMD were 11 and 52%, respectively. Close clipping of the forage allowed for a faster rate of regrowth and greater seed production the following year. The hay could be used during the summer when pasture quality decreases.

The palatability and yield of tall fescue pastures in the summer can be increased by planting a legume with the fescue. Dobson et al. (1976) grew tall fescue alone and in combination with crownvetch, white clover, red clover and birdsfoot trefoil. Fescue grown in pure stands yielded 4.5 metric tons of dry matter per hectare, while yields for all combinations of fescue and legumes were markedly higher. Highest yields were reported for fescue-red clover for the first year, with yields decreasing with a loss of red clover in the second and third years. Red clover normally does not last more than 2 years and should possibly be treated as an annual. The other legumes planted with fescue also tended to decrease as expressed on a percentage basis with the exception of crownvetch which was maintained. Bryant et al. (1977) reported crownvetch to be a high yielding, palatable legume when grazed at or before the prebloom stage of growth with cattle maintained on these pastures exclusively. Cattle gains were .8 and .63 kg per day for Angus steers grazing crownvetch plots, indicating satisfactory weight gains. Crownvetch may be a suitable legume for planting with tall fescue, especially as a hay crop (Burns et al., 1969). Crownvetch forage contains high levels of tannins and phenols which have been shown to decrease plant palatability and digestibility but these chemicals are largely inactivated by field curing (Burns and Cope, 1974).

Hughes (1955) drilled in tall fescue and alfalfa in alternate .3 m wide strips. Grazing sequence of the pasture included grazing fescue early in the spring before alfalfa started to grow, with rotational grazing during the summer in small lots to maximize forage utilization. Stockpiling the pasture was begun in August to allow for good autumn accumulated fescue and to allow establishment of the alfalfa for the following year. The average number of animal grazing days per hectare over a 4 year period was 404, plus an excellent hay crop. Fescue and alfalfa planted together would also decrease problems of bloat associated with ruminants consuming pure stands of alfalfa (Kendall and Leath, 1976). Management systems for alfalfa of this kind would have several good varieties of alfalfa which could be used in a grazing scheme (Wilson et al., 1978).

Antiquality Factors

Numerous antiquality factors have been identified in pastures and forages including those previously mentioned. Of special importance in the context of this manuscript is problems related to fescue foot. Stearns (1953) reported numerous cases of fescue foot were identified by farmers in Kentucky following a drought year. In one herd alone, 8 of 30 cattle showed symptoms of the ergot poisoning-like disease. Symptoms of the disease included swelling of both hind legs from foot to hock, extension of hind legs, lameness and sloughing of the tail. The fore feet were usually unaffected. The disease is non-infectious and characterized by a dry gangrene of the rear feet and tail. Watson et al. (1957) allotted 119 beef steers to three fescue pastures. Grazing of the pastures was begun in early June after a first hay cut. The first incidence of fescue foot did not occur until December, after fescue had been thoroughly frosted and the ground frozen. The causative factor of the fescue foot syndrome was not isolated but the action of a vasoconstrictor has been suggested (Jacobson et al., 1963).

Garner et al. (1978) in Missouri have isolated a substance from fescue using ethanol extraction and an anion resin exchange column. The resin contains virtually no alkaloids or lipid-like substances. Fescue foot symptoms were observed following subcutaneous injections of the extract within 8 to 13 days.

Bush et al. (1969) and Bush et al. (1972) reported perloline to be the major alkaloid present in fescue causing a depression in cellulose digestibility. Perloline levels of 9.1×10^{-5}, similar to levels in late summer fescue depressed in vitro cellulose digestibility.

Stritzke et al. (1976) reported nitrogen fertilization will increase nitrate levels in the plant while decreasing total non-structural carbodhyrates. Fescue and wheat were both grown with 0, 30, 47, 63, 80 and 94% shading using a Saran shade. Shading levels of 94%

plus nitrogen fertilization resulted in nitrate concentrations of 9000 and 4000 ppm for fescue and wheat, respectively. Shading levels above 30% plus nitrogen fertilization resulted in high nitrate concentration while shading levels of 63% and above without nitrogen fertilization were required to elevate nitrate levels. They indicated that toxic nitrate levels above 2100 ppm in forages were reported to be toxic (Wright and Davidson, 1964).

Bloat is a critical problem in grazing pure or legume-dominant pastures which may lead to economic losses caused by lowered animal production (Lindahal et al., 1954). Problems of bloat may be prevented by feeding long hay, planting grass, or making poloxalene available in legume pastures. Legume bloat does not occur with the same frequency in legume hay compared to fresh legume forage (Bartley, 1967).

Kentucky researchers (Hojati et al., 1977) fertilized bluegrass and tall fescue pastures with 50, 100, 150 and 200 kg of nitrogen per hectare. At high nitrogen levels, calcium, phosphorus and potassium were present at adequate levels for animal needs, but magnesium content was decreased. This decrease in magnesium was most dramatic in bluegrass, indicating a potential for grass tetany.

Perdromo et al. (1977) found that as tropical forages increase in maturity, availability of magnesium and iron are decreased. One of two similar plots of pangola grass received calcium fertilizer. Forage from plots not receiving calcium fertilization was supplemented with calcium upon feeding of the dried forages. Organic matter digestibility was increased with pangola grass fertilized with calcium, compared to control although the calcium intakes were similar (Rees and Minson, 1976). The authors suggested there was an unidentifed structural change brought about by calcium fertilization. Certainly, changes of this nature would not be expected unless soil calcium levels were initially limiting.

Owen et al. (1976) fed either chopped tall fescue or orchardgrass which had been harvested in early September to Holstein steers in environmentally controlled housing. These workers found rate of eating and total dry matter intakes were lower for fescue than orchardgrass at either 18 C or 32 C. Cattle tended to spend less total time eating but ate at a faster rate under high temperatures. Hemicellulose levels were 27.0 and 23.5% for fescue and orchardgrass, respectively, indicating hemicellulose as a possible antiquality factor.

Forage Finishing Systems

Wise et al. (1967) compared different levels of corn grain supplemented at 0, .5, 1.0 and 1.5% of bodyweight to growing-finishing steers grazing ladino clover or fescue-ladino clover pastures. Daily gains increased with increasing supplemental grain levels up to 1% of bodyweight. Gains were similar between steers fed grain at either 1.0 or 1.5% of bodyweight. Steers grazing ladino clover had higher gains, except where no grain was supplemented, than steers consuming fescue-ladino clover pastures. Mott et al. (1971) supplemented corn grain at 1% of bodyweight to steers grazing fescue pastures. Average daily gains were significantly increased along with increased carrying capacity and gains per hectare.

Several systems for growing beef cattle on pasture with various supplements and finishing in a drylot were evaluated in Colorado by Denham (1977). Daily gains of Hereford steers were increased by grain supplementation in the spring and by protein supplementation in the fall. Spring, summer and fall grain supplementation or spring supplementation decreased subsequent feedlot performance while fall protein supplementation during the latter stages of the growing phase increased gains on pasture but did not affect subsequent feedlot gains. This resulted in a heavier final weight of the animals, suggesting digestible protein could have been limiting in the forage.

"Seewannee" bermudagrass was fed as hay harvested at 4, 6, 8 or 10 weeks of regrowth with one-half the animals on all hay treatments receiving grain supplementation (Golding _et al_., 1976). Grain was supplemented to supply 50% of the estimated digestible energy intake. Gross energy intake and digestibility of hay alone decreased with increasing maturity. Gross energy digestibility was also depressed at 4, 6 and 8 weeks but not at 10 weeks of regrowth when hays were supplemented with grain. Digestible energy depression was greatest with the highest quality hay and progressively less with increasing maturity, suggesting grain supplementation maximizes energetic efficiency in poorer quality forages.

Bidner _et al_. (1977) reported forage fed Angus and Angus-Hereford steers and heifers were lighter than steers of the same age finished on drylot with grain for 70 or 140 days. Carcasses from grass fed beef had lower quality grades and slightly less tender meat.

Bidner et al. (1978) compared all forage diets to forage plus a 70-day feedlot period, forage plus grain at 1% bodyweight, and forage with grain at 1% bodyweight plus 70-day feedlot finishing. Initial steer weights were 225 kg with final weights of 480 kg for all treatments. Days on test ranged from 287 days for steers with forage and 1% grain plus a 70-day finishing period to 465 days for steers fed all forage diets. Forage finished steers had less marbling and lower quality grades but were similar in Warner-Bratzler shear scores and consumer taste panel rating.

The production of beef steers using 10 management systems ranging from minimum grain feeding with steers grazing pasture to all concentrate feedlot finishing regimes for the evaluation of production and carcass characteristics of steers were evaluated in Texas (Bowling et al., 1978). One group of 10 weaned Santa Gertrudis steer calves were slaughtered as calves. Steers fed grain in drylot reached market weight 100 to 230 days earlier with a higher carcass grade and dressing percent but, a lower percentage of primal cuts than systems using forages, sorghum silage or grain on grass. Steers grown on grass or grain on grass were older when slaughtered at a comparable weight and were lower and more variable in meat palatability as judged by a taste panel. The best management system for the economic production of beef was to maximize growth and frame development of steers on forage, followed by a period of drylot finishing on grain.

Thirty pairs of carcasses from steers fed either forage or grain as the primary energy source of similar USDA carcass grades were evaluated. Grain fed beef was more tender with more flavor and fat covering than steers fed forage (Bowling et al., 1977). Chilling one side of the forage fed beef at a colder temperature significantly decreased shear force compared to the other side of the carcass chilled at the average cooler temperatures. The reason for this finding was not evident, but it did not occur in grain fed beef.

OBJECTIVES

Experiments were conducted to evaluate chemical changes in forages and relate them to performance of growing-finishing steers on pasture and to evaluate the palatability and nutrient availability of fescue forage.

The specific objectives were:

1. To characterize yield and quality of stockpiled fescue-red clover during the entire winter.
2. To relate animal performance to changes in grass-legume pasture mixtures in the winter and summer.
3. To evaluate palatability and nutrient digestibility of tall fescue at four times during the year.

MATERIALS AND METHODS

This research was composed of two phases: (1) growing-finishing beef steers with forage as the primary energy source with little or no grain supplementation, and (2) the palatability and nutrient availability of tall fescue forage growing at four times during the year. The growing-finishing studies using forage were conducted at two locations, Middleburg and Glade Spring, Virginia. Palatability and nutrient availability trials were conducted using facilities at the Agronomy Farm, Smithfield Barn and the Metabolism Unit, all in Blacksburg. The tall fescue (Festuca arundinacea Schreb) used in all studies consisted of Kentucky 31 cultivar. Hereafter the term fescue will be used.

Beef Steer Finishing

Forage-Animal Management Systems

The beef steer growing-finishing project in which animals consumed mainly forage was conducted at two Virginia soil-climatic-biotic ecosystems with seven systems for producing fat steers at different times of the year. The systems included four cattle-forage groups with weanling steers and three groups with yearling steers (table 1).

Weanling calves were randomly allotted within blocks based on liveweights to systems 1, 2, 3 and 4 at both locations. Grazing stockpiled fescue-red clover (Trifolium pratense L.) pastures was begun on November 18, 1976, and continued through mid-April. Sequence grazing

TABLE 1. CATTLE-FORAGE MANAGEMENT SYSTEMS AT TWO VIRGINIA LOCATIONS WITH WEANLING CALVES AND YEARLINGS

System number	Kind of steers, fall, 1976	Type of grazing	Grain level, % of bodywt.	Time of slaughter
1	Weanling calves	Top	0	½ Oct.-½ Jan.
2	Weanling calves	Top	.5	½ Oct.-½ Jan.
3	Weanling calves	Whole	0	½ Oct.-½ Jan.
4	Weanling calves	Whole	.5[a]	½ Oct.-½ Jan.
5	Yearlings	Whole	.5[a]	July
6	Yearlings	Top	0	July
7	Yearlings	Whole	1.0	April

[a]Increased to 1.0% of bodyweight in April

of either bluegrass(*Poa pratensis* L.)-white clover(*Trifolium repens* L.), orchardgrass(*Dactylis glomerata* L.)-alfalfa(*Medicago sativa* L.) or fescue-red clover was conducted from mid-April to October. The grazing period was followed by a short period of finishing on corn grain (IRN4-02-879) for one-half of the steer calves, except in systems where cattle had reached U.S.D.A. choice grade. Systems 1 and 2 were both top grazers receiving grain at 0 and .5% bodyweight, respectively. Systems 3 and 4 were whole plant grazers, receiving grain at 0 and .5% bodyweight, respectively. Grain supplementation was increased to 1% in April for steers in system 4.

The cattle in systems 5, 6 and 7 were yearling steers randomly allotted to their respective treatments from blocks based on liveweight. All systems grazed stockpiled fescue-red clover pastures from November 18, 1976, until April, 1977. Steers in system 5 were whole plant grazers receiving grain at .5% bodyweight through the winter and increased to 1% grain in April. Animals in this system were scheduled for slaughter as finished steers in July. System 6 contained top grazers receiving no grain with July as a scheduled slaughter date. Whole plant grazers receiving 1% grain (system 7) were to be slaughtered in May. Animals in this system were maintained exclusively on fescue-red clover pastures. Systems 5 and 6 grazed bluegrass-white clover, orchardgrass-alfalfa and fescue-red clover pastures in various sequences during the spring and summer after winter grazing of fescue-red clover. Steers in systems 1 and 6 and 4 and 5 were grazed together due to similarities in systems.

Land Allotment

Area allotments per system and general diagram of the pastures at Glade Spring and Middleburg are presented in figures 1 and 2, respectively. The cattle in each management system at Glade Spring had access to two permanent fescue-red clover pastures while those at Middleburg had access to three, but total available area was the same at both locations.

Establishment of Pastures

At Glade Spring, pastures were established in April, 1976, preceding the initiation of grazing experiments begun in November, 1976. At Middleburg, bluegrass-orchardgrass-white clover pastures which had been established for several years were used. Fescue-red clover and orchardgrass-alfalfa pastures were established in the fall of 1975. Fertilizer was applied to equilibrate all pastures for soil pH, phosphorus and potassium content. Soil samples were obtained and anaylzed from each lot for determining fertilization needed. General fertilization schemes included 4.5 metric tons of lime and 1120 kg of 0-20-10 fertilizer per hectare. In addition, all orchardgrass-alfalfa plots received 16.8 kg boron per hectare. Seeding rates were 4.5 kg orchardgrass seed, 20.2 kg fescue and 6.7 kg red clover for pastures at Glade Spring. At Middleburg no orchardgrass was seeded in the fescue-red clover plots. Bluegrass-orchardgrass-white clover pastures were seeded with 16.8 kg of bluegrass, 2.2 kg of ladino clover, 1.1 kg of white clover and 5.6 kg of orchardgrass seed per hectare. Alfalfa and orchardgrass were seeded at rates of

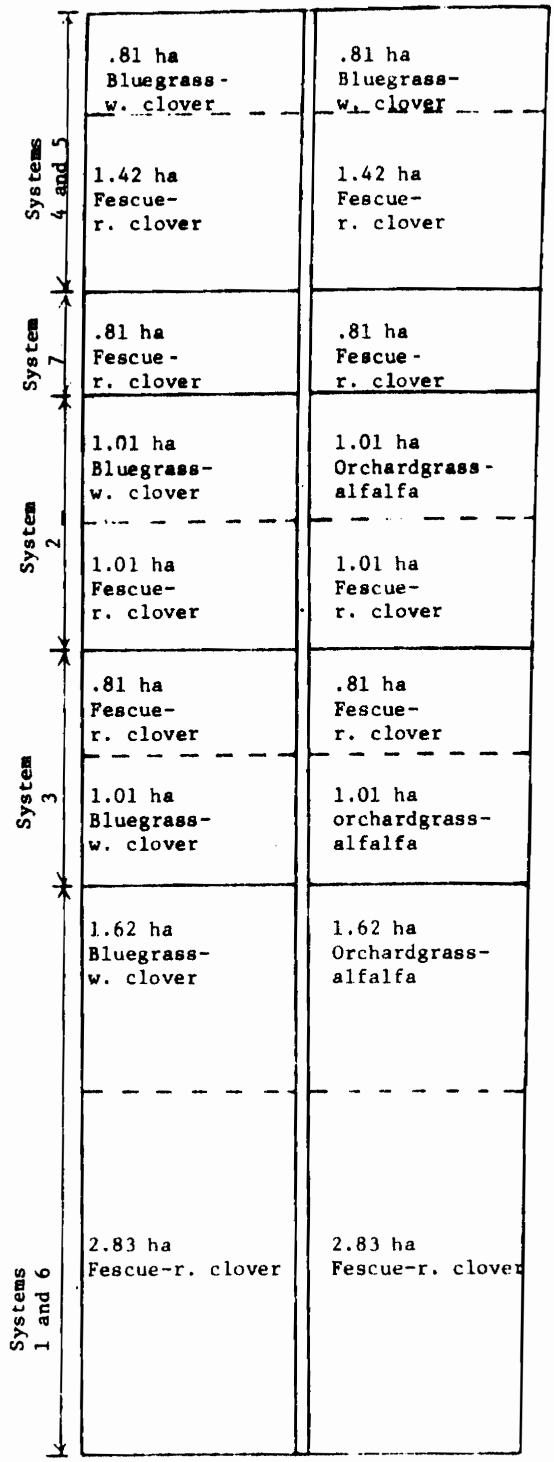

FIGURE 1. PASTURE DESIGN OF FORAGE FINISHING SYSTEMS AT GLADE SPRING

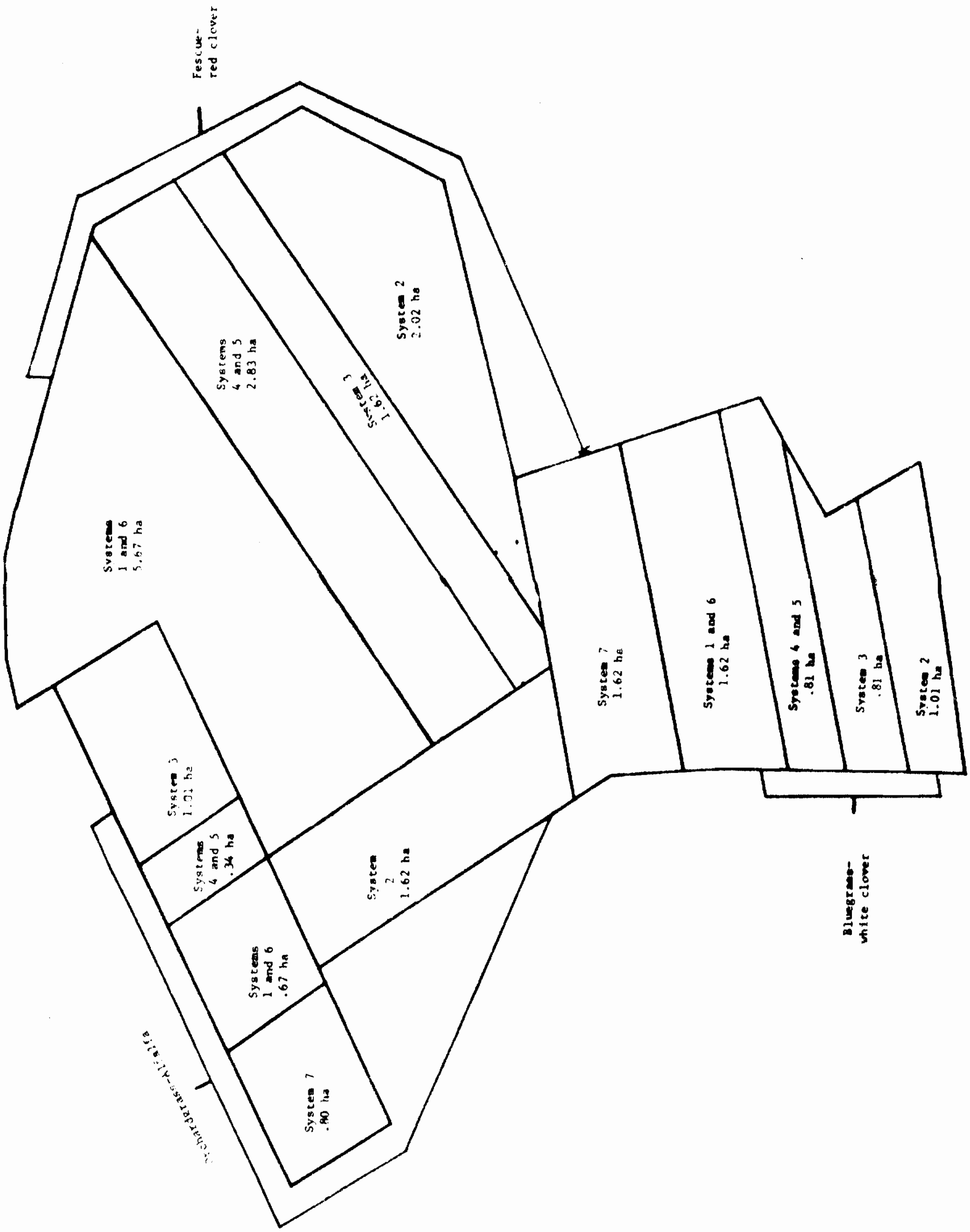

FIGURE 2. PASTURE DESIGN OF FORAGE FINISHING SYSTEMS AT MIDDLEBURG

20.2 and 4.5 kg per hectare, respectively, in the orchardgrass-alfalfa pastures. All seeds were certified.

Management of Pastures

All systems within each location were designed to be managed independently. General grazing patterns for all systems included grazing stockpiled fescue-red clover pastures during the wintering phase from November to April. During the spring and summer, bluegrass-white clover, orchardgrass-alfalfa and fescue-red clover were used in a sequence grazing pattern with cattle allowed to graze high quality pastures. The excess growth of fescue-red clover and orchardgrass-alfalfa was cured as hay and credited to the systems. Fescue-red clover pastures grazed or harvested for hay in early August were fertilized with 112 and 72 kg of nitrogen per hectare at Glade Spring and Middleburg, respectively. The fescue was accumulated for winter grazing. During the wintering phase at Glade Spring, temporary fences were used to divide one of the two pastures per system. Heavy trampling losses were observed in these smaller paddocks, so no other pastures were subdivided.

Sampling and Analysis of Forage

All pastures were sampled immediately before and after grazing with steers. Samples were taken randomly tossing a 1 m stick within one of four quadrants within each pasture. Each quadrant was estimated to constitute roughly one-fourth of the pasture with five to seven samples being harvested and composited within each quadrant. The harvesting of 20, 24 or 28 samples from each pasture was associated with pasture size, with the most samples being taken from largest pastures. Samples were taken by cutting a 1 m strip 10 cm wide, with electric hand clippers. At Glade Spring the samples were harvested at a 2 cm height and at Middleburg the samples were cut at ground level during the wintering phase and at 2 cm thereafter. Sampling at 2 cm height approximates forage available for grazing, and cutting at ground level estimates total forage present. The final pastures to be grazed during the winter at Glade Spring were designated as reference plots. Each of the five reference plots was sampled at day 0 (November 18, 1976), 25, 99, 125 and 140. Changes in total dry matter yield and nutrient composition of fescue-red clover pasture during the winter was determined. Sampling for forage quality during the winter was less extensive in Middleburg than at Glade Spring. On day 99 during the wintering study at Glade Spring, the steers were allowed access to the reference plot. At that time, 1.2 x 1.2 m wire cages were placed in the reference plots. One-half the forage under the cage was harvested on day 125 and the other half on day 140.

After harvesting samples at Glade Spring, the forage was transported to Blacksburg. Visible dirt, fecal material and extremely stemmy weed material were removed before a subsample was taken for determining botanical composition. Grasses and legumes were hand separated to ascertain botanical percentages. This along with visual estimations at times of sampling the pastures, gave estimates of the percentages of grasses, legumes and weeds in each pasture. After separation, the grass and legume samples were dried and stored for analysis. In this study a weed was defined as a plant species considered to be lower in quality and palatability than the forage plants in a pasture. This modified definition was used because alfalfa would not be considered a weed if found in a fescue-red clover pasture.

Samples harvested at Middleburg were dried at the Station, labeled, and sent to Blacksburg. Botanical estimates by visual and plant heights were taken within a 2 m radius from the sampling area.

Forage samples were dried in a forced air drying oven at 53 C for a minimum of 24 hours. Dry weights, including all botanical components, were used to estimate yield per hectare from each pasture. Samples were analyzed for dry matter, ash, Kjeldahl nitrogen (A.O.A.C., 1975), neutral detergent fiber (Van Soest and Wine, 1967), acid detergent fiber (Van Soest, 1963, and Georing and Van Soest, 1970), permanganante lignin, cellulose and residual ash (Van Soest and Wine, 1968), and total nonstructural carbohydrates (Harvey *et al*., 1969, as modified by Wolf and Ellmore, 1973, 1975). *In vitro* dry matter digestibility was determined using the methods of Tilley and Terry (1963) with modifications by Barnes (1969) and a buffer solution described by McDougall (1948). Values between runs were standardized using an alfalfa hay reference standard. All chemical component values, unless otherwise stated, are on a dry matter basis.

Cattle Management

Steers in the forage-animal management systems designated to be top grazers remained on a pasture until 50 to 60% of the available forage had been consumed. Whole plant grazers were expected to graze about 80% of the available forages or until less than 700 kg of dry matter per hectare remained.

Steers at both locations were weighted at 14 day intervals. The weights were used to calculate the amount of grain to be supplemented. Salt was mixed with the ground corn grain to limit intake so animals could be fed on a weekly basis to reduce labor.

All animals were graded live by a state grader prior to slaughter. Slaughter parameters measured were chilled carcass weight, dressing percent, loin eye area, fat thickness over the loin eye, carcass quality and yield grades.

Metabolism and Palatability Trials

Two metabolism and four palatability trials were conducted to evaluate nutrient digestibility and voluntary dry matter intake of fescue at four harvest times during the year.

Description, Fertilization and Management of the Fescue Plot

A .5 hectare plot of established fescue measuring 22 by 218 m, located at the Agronomy Farm in Blacksburg, was used as a forage source. On April 4, 1977, the plot was mowed, and the dead material was raked off prior to obtaining a soil sample. The plot was fertilized with 56 kg each of nitrogen, phosphorus and potassium on April 13, 1977, according to soil test results. The plot area was closely examined and only areas containing "typical" fescue forage were used for the palatability and digestion trials. The suitable fescue area was then subdivided into 15 strips of equal area for each of the May and July trials and 30 strips for the November and February trials (15 strips for each trial).

After the May and July trials were completed, the entire plot was mowed and all material was removed. Soil samples were taken again, but the soil test indicated that phosphorus, potassium and soil pH were adequate. On August 11, 1978, 101 kg of nitrogen per hectare were applied and the forage was allowed to accumulate. The stockpiled fescue was used in palatability and metabolism trials in November and February.

Harvesting and Processing Fescue Forage

The plots were harvested with a small Gravely tractor with a sicklebar attachment. Forage for each palatability trial was harvested daily at random from one of the 15 available areas. Forage was always harvested from the right-hand side of the designated area for the palatability trial. The forage was put through a forage chopper after harvesting and before being fed to the wethers.

Forage for the metabolism trials to be conducted at a later date was harvested on 1 day, coinciding with the midpoint of the palatability measurement period. The forage was dried in forced air drying ovens at 53 C for 24 hours. The dried forage was placed in burlap bags and stored.

Alfalfa Reference Hay

Alfalfa hay was fed in each of the palatability trials as a reference feed. The reference hay was fed to standardize comparisons of palatability of fescue harvested at different times of the year. The alfalfa hay was obtained from a common source with bales being randomly allotted to each of the four palatability trials. The hay was ground through a 2.5 cm screen just prior to the beginning of each trial.

The alfalfa hay reference feed was also fed in each of the two metabolism trials. A measure of digestible dry matter intake of fescue consumed relative to voluntary digestible dry matter intake of alfalfa was obtained.

Metabolism Trials

Five experimental rations were fed in each metabolism trial, including dried fescue forage from four harvest dates (May 23, 1977, August 1, 1977, November 16, 1977 and March 4, 1978) and the alfalfa reference hay. All dried fescue forages and the alfalfa hay were ground through a 2.5 cm screen.

Fifteen crossbred wethers were blocked according to weight and breed and randomly allotted within blocks to five experimental rations for each of the two trials (six animals per treatment). For the second trial, randomization was restricted so no animal would remain in the same treatment as during trial 1.

Experimental rations were fed to wethers in individual metabolism crates at the rate of 700 g of air-dry feed per day. Animals were fed twice daily at 12-hr intervals with water available at all times except during the 2-hr feeding periods. Salt was added at each feeding at the level of 5 g per feeding. Metabolism trials consisted of a 2-day adaptation period to the stalls, a 4-day transition period to the experimental rations, a 10-day preliminary period and a 10-day collection period. Total feces and urine were collected once daily during the collection period. The feces were dried for 24 hr in a forced-draft oven at a maximum of 60 C, and stored in cans with loosely fitted lids to allow moisture equilibration. Urine was collected in 15 ml of 1:1 (w/w) sulfuric acid and water diluted to 500 ml. Daily collections were diluted to a constant weight with water and a 2% samples was taken and stored under refrigeration. Rumen fluid samples were taken on day 10 of the collection period, 2 hr after feeding. Animal weights were recorded on day 8 of the preliminary period and immediately after the end of the collection period.

Feeds and feces were analyzed for dry matter, crude protein, ash, cell walls, acid detergent fiber, permanganate lignin, cellulose, hemicellulose and residual ash according to methods described above. Rumen fluid was analyzed for ammonia (Conway, 1958) and volatile fatty acids (Erwin *et al.*, 1961).

Palatability Trials

Palatability trials were conducted with freshly cut forage to evaluate voluntary intake of fescue from May 7 to 26, 1977, July 21 to August 4, 1977, November 3 to 22, 1977 and February 12 to March 1, 1978. Each palatability study consisted of a 2-day adaptation period to the stalls, a 2-day transistion period to the experimental ration, a 5-day preliminary period and a 10-day measurement period. The sheep were paired on the basis of weight for the May and July trials and on the basis of breed and weight for the November and February trials. For each trial, 12 crossbred wethers were randomly allotted to the two forages and to 1.3 by 4 m individual pens in an enclosed barn. Water and salt were provided at all times. Wethers used in the May and July palatability trials were heavier, more mature sheep, 15 and 18 mo of age, respectively. Sheep used in the November and February trials were ligher, and 9 and 12 mo of age, respectively. Animals were fed at 12 hr intervals at 10% in excess of comsumption on the previous day. Refusals for each animal were collected and dried daily. Individual sheep weights were obtained on days 0 and 10 of the measurement period. Dry matter intake of fresh fescue for each wether was recorded as a percentage of the pair-fed wether fed alfalfa reference hay and expressed on a metabolic weight basis ($Wt_{kg}^{.75}$).

Fescue forage used in the four palatability trials was analyzed for total nonsturctural carbohydrates, crude protein, crude fiber, ether extract, ash, neutral and acid detergent fiber, permanganate lignin, cellulose and hemicellulose and residual ash as previously described.

Data for metabolism and palatability trials were treated by analysis of variance (Snedecor and Cochran, 1967). The multiple range test of Duncan (1955) was used to test for significant differences among treatment means.

RESULTS AND DISCUSSION

Evaluation of Forage-Animal Management Systems-Winter

Stockpiled Mixtures of Fescue-Red Clover-Glade Spring

Chemical Composition. Nutrient composition of stockpiled fescue-red clover pastures at Glade Spring during the winter are presented in table 2 . Total nonstructural carbohydrate values showed a dramatic decline (P <.05), especially after December. The levels were 13.6% and 10.4% in November and December, respectively, but declined to 4% or less thereafter. These decreases in total nonstructural carbohydrate contents were very similar to those reported by Taylor and Templeton (1976). These Kentucky researchers found total nonstructural carbohydrate levels decreased from 13% on December 1 to 3.8% on March 2. The decline in carbohydrate levels reported by these workers was accompanied by a decrease in *in vitro* digestibility. The high solubility of nonstructural carbohydrates probably accounts for rapid losses during the winter. The loss of nonstructural carbohydrates is very important, as this component has been reported to be positively related to palatability and digestibility (Bland and Dent, 1962, and Younger and Nudge, 1976).

Increases in cell wall contents, acid detergent fiber, hemicellulose and lignin were recorded as the winter progressed, with generally highest levels at the February sampling. Cellulose levels tended to remain stabe during the winter, indicating some losses. With decreases in the total nonstructural carbohydrate content, any

TABLE 2. NUTRIENT COMPOSITION OF STOCKPILED FESCUE-RED CLOVER.[a] GLADE SPRING

Component	Sampling date				
	11-18-76	12-13-76	2-25-77	3-23-77	4-6-77
	%	%	%	%	%
Crude protein	15.7^{b}	16.8^{b}	15.8^{b}	15.3^{b}	21.0^{c}
Total nonstructural carbohydrates	13.6^{b}	10.4^{c}	3.7^{d}	3.2^{d}	4.0^{d}
Cell walls	48.8^{b}	55.4^{c}	67.1^{d}	69.4^{d}	58.4^{c}
Acid detergent fiber	28.4^{b}	33.1^{c}	41.9^{d}	40.6^{d}	34.0^{c}
Hemicellulose	20.3^{b}	22.2^{b,c}	24.3^{c,d}	28.8^{d}	23.1^{c}
Cellulose	24.6^{b}	25.9^{b}	24.7^{b}	25.1^{b}	24.2^{b}
Lignin	4.3^{b}	5.7^{c}	8.1^{d}	7.6^{d}	6.1^{c}
Residual ash	1.2^{b}	1.9^{b}	8.6^{c}	7.7^{c}	3.0^{b}
Ash	6.9^{b}	6.8^{b}	14.1^{c}	13.7^{c}	12.0^{c}

[a]Percentage of red clover was 13, 16, 27, 21 and 17% for 11-18-76, 12-13-76, 2-25-77, 3-23-77, and 4-6-77, respectively.

[b,c,d]Means in the same line with different superscript letters are different ($P < .05$).

component maintaining its absolute content would show an increase on a percentage basis. It appears that some, and probably the most soluble portion of the cellulose was lost. Cellulose, a part of plant fiber, does not necessarily represent a more indigestible fraction of the structural polysaccharides of fiber (Van Soest, 1965b).

Crude protein content remained constant over the winter. These results agree with those of Taylor and Templeton (1976) who reported crude protein content remained between 10.5 to 11% from December to March. Archer and Decker (1977b) reported that crude protein declined slightly during the winter. Crude protein levels at Glade Spring for stockpiled fescue-red clover could have been slightly lower than reported. Although samples were taken in February, 2 days after the snow cover had melted, red clover regrowth had begun. This new clover growth, included with the sample was undoubtly high in crude protein content.

The silica content had been high in February and March and suddenly declined in April, but the ash values were still high at that time. There is generally a close relationship between ash and residual ash components of forages (Van Soest and Jones, 1968). The residual ash component contains silica as a major component while ash values are higher as all minerals are present. Archer and Decker (1977b) reported silica increased 3.3 percentage units in winter burned leaf material. Taylor and Templeton (1976) reported protein content of senesced tissue to be higher than in green portions.

<u>In Vitro Dry Matter Digestibilities and Yields</u>. Values for stockpiled pastures at Glade Spring are shown in table 3 . <u>In vitro</u>

TABLE 3 . IN VITRO DRY MATTER DIGESTIBILITY AND YIELD OF STOCKPILED FESCUE-RED CLOVER-GLADE SPRING

Sampling date	*In vitro* digestibility	Yield per hectare	
		Dry matter	Digestible dry matter[e]
	-%-	kg	kg
11-18-76	69.5[a]	3893[a]	2705[a]
12-13-76	65.5[b]	3987[a]	2609[a]
2-25-77	48.7[c]	3328[b]	1622[b]
3-23-77	50.2[c]		
4-6-77	59.7[d]		

[a,b,c,d]Mean in the same column with different superscript letter are different ($P < .05$).

[e]Calculated from *in vitro* digestibility and dry matter yield.

dry matter digestibility was highest (P< .05) in November. The lowest values occurred in February and March (P< .05) and the levels increased in April, perhaps due to the regrowth of the forage. Color changes in the forage appeared to be a good indicator of forage quality over the winter. During November fescue was mostly green with some browning of the tips, but by December the dead material in forage increased and digestibility declined. Heavy snows covered the pastures at Glade Spring from late December to late February. Samples taken in February and March were almost totally composed of dead plant tissue, and *in vitro* digestibility was lowest at that time. April samples contained dead material along with regrowth, mainly red clover. The dead material resulted from rupturing of the plant cell from alternating freezing and thawing, with the formation of ice crystals in the cells. Archer and Decker (1977a) reported a 10 percentage unit decrease in *in vitro* digestibility from October 10 to December 24. These Maryland researchers (Archer and Decker, 1977b) also reported that each 10 percentage unit increase in the amount of dead leaf material present resulted in a 3.4 percentage unit decrease in *in vitro* digestibility. Increased levels of cell wall contents, acid detergent fibe, lignin and silica were present in brown leaf material, compared to green material.

Total dry matter yields increased slightly from November to December, probably due to sampling error. Yields were decreased by 20% in February, compared to November and December (P <.05). Balasko (1977) in West Virginia reported a 10% decrease in the yield of fescue from December to January. Corbett (1957) reported dry matter losses during the winter were 10 to 20% for orchardgrass and 40% for ryegrass. He indicated that loss in dry matter is due to more rapid rate in plant senescence than new growth. Dry matter losses agree with nutrient compositon data (table 2).

The digestible kilograms of dry matter per hectare were much lower in February than either November or December ($P <.05$). This was due to a combination of lower yields plus a sharp decline in dry matter digestibility. Gardner and Hunt (1955) reported in Scotland that grazing of stockpiled forages should be completed by January 1. Similar recommendations should probably be made in Virginia if a high quality feed source for animal consumption is the main objective.

Pure Fescue and Red Clover. The *in vitro* digestibility and crude protein contents of fescue and red clover samples obtained by hand separation of fescue-red clover samples are given in table 4 . Crude protein in fescue tended to decrease in late winter, which agrees with the data of Archer and Decker (1977b). Crude protein of red clover tended to decrease more rapidly in the winter and increase more rapidly in spring due to earlier regrowth. Individual *in vitro* digestibility data are lower than the component means of the forage mixtures, indicating samples were not truly representative. It appears that much of the decline in *in vitro* digestibility over the winter was from the red clover fraction. Red clover loses much of the leaf material early in the winter due to leaf-drop caused by frost.

TABLE 4. CRUDE PROTEIN CONTENT AND INVITRO DRY MATTER DIGESTIBILITY OF STOCKPILED FESCUE AND RED CLOVER. GLADE SPRING

Sampling date	Crude protein content		Dry matter digestibility[a]	
	Fescue	Red Clover	Fescue	Red Clover
	-%-	-%-	-%-	-%-
11-18-76	16.3	22.5	62.5	56.2
12-13-76	15.4	14.5	63.2	50.9
2-25-77	13.2	16.8	56.3	41.8
3-23-77	14.1	29.4	55.2	66.1
4-6-77	17.2	28.8	61.9	77.3

[a]Determined *in vitro*.

Stockpiled Mixtures of Fescue-Red Clover-Middleburg

Chemical Composition. The composition of stockpiled fescue-red clover pastures at Middleburg is shown in table 5 . Sample dates were more frequent at Middleburg than Glade Spring, but the number of samples per date were fewer. Very similar changes in nutrient composition were obtained between the two research stations. Total nonstructural carbohydrates were higher in all periods at Middleburg than Glade Spring. Middleburg samples were harvested at ground level while those at Glade Spring were harvested 2 cm above ground level. Total nonstructural carbohydrate reserves are generally highest in the augment basal areas of the plants (Smith, 1977); thus, close cutting would augment carbohydrate content. The higher nonstructural carbohydrate levels at Middleburg may also be attributed to the less severe winter weather and less snow accumulation.

The recovery of fescue-red clover pastures began earlier in Middleburg than Glade Spring, as indicated by carbohydrate and *in vitro* digestibility data. Interesting to note is the comparison between nonstructural carbohydrate levels in the fall, late winter and spring. Brown *et al*. (1963) reported stockpiled fescue increased from 9 to 21% from 2 to 11 weeks, respectively, after stockpiling was begun. Increasing nonstructural carbohydrate levels occurred with cooler temperatures and a decline in growth rate. Data from Middleburg shows nonstructural carbohydrate levels increased in mid-to late February. Apparently the temperature was warm enough for photosynthetic activity but too cold for rapid growth. Total nonstructural carbohydrates

TABLE 5 . NUTRIENT COMPOSITION OF STOCKPILED FESCUE-RED CLOVER.[a] MIDDLEBURG

Sampling date	Component						
	TNC[b]	IVDMD[c]	Crude protein	Cell walls	ADF[d]	Lignin	Cellulose
	%	%	%	%	%	%	%
11-16-76	19.0	73.8	15.4	45.4	27.6	6.3	19.8
12-8-76	11.1	70.9	14.5	55.7	32.8	6.3	24.9
12-29-76	6.1	61.0					
1-4-77[e]	6.3	55.9					
2-1-77[e]	7.2	53.0	14.1	70.7	42.9	9.3	25.5
2-10-77	8.3	56.2	17.2	68.5	39.8	11.1	25.7
2-24-77	11.5	57.9	14.2	63.1	43.9	7.2	24.1
3-1-77	3.5	54.0	16.2	65.8	44.4	10.8	25.3
3-23-77	4.9	62.4	21.3	60.4	42.2	9.8	20.7
4-6-77	4.6	63.4	19.2	52.0	34.4	10.0	20.9

[a]Percentage of red clover was 41, 35, 29, 60, 39, 53, 11, 41, 52 and 50 for 11-16-76, 12-8-76, 12-29-76, 1-4-77, 2-1-77, 2-10-77, 2-24-77, 3-1-77, 3-23-77, and 4-6-77 respectively.
[b]Total nonstructural carbohydrates.
[c]*In vitro* dry matter digestibility.
[d]Acid detergent fiber.
[e]Samples were too small for other analyses.

increased until accelerated growth began in March and April, when carbohydrate levels declined.

The values for the various fiber components, cell wall contents, acid detergent fiber, lignin and cellulose, are similar to those reported for Glade Spring. Fiber levels were expected to be slightly higher at Middleburg because of the lower sampling height, but this must have been counterbalanced by the higher total nonstructural carbohydrate content. Fiber levels at Middleburg tended to decrease sooner in late winter indicating an earlier regrowth of plants in the milder winter climate, compared to Glade Spring.

In Vitro Dry Matter Digestibilities. *In vitro* digestibility was highest in November, declined slightly in early December, and declined 10 to 15 percentage units in late December and early January. These samples were harvested after the first severe winter weather of snow and cold temperatures. Digestibilities remained low until late February, indicating some new plant growth was occurring.

It appears from the Middleburg data that most of the detrimental effects of winter on plant quality occurred during the last week of December. After this date, forage appeared to be in a dormant stage and maintained a constant nutritive value during the remainder of the winter.

Consumption by cattle of the upper leaf portions of fescue and red clover early in winter could maximize quality. Lower portions of the plant generally contain a higher fiber level and would be less adversely affected by winter burn. Golding *et al*. (1976) reported supplementing grain to account for 50% of the digestible energy intake of beef cattle fed four hays ranging from high to low quality. Depression in digestible energy intake from hay was greatest with high quality hay. Extrapolating these data to the present steer finishing study, it would seem advisable to minimize grain supplementation in early winter when pasture quality is highest and increase grain supplementation in late winter when forage quality is lowest.

Wintering Beef Steers

Cell Wall Contents and Acid Detergent Fiber. Cell wall contents and acid detergent fiber composition of initial (before grazing) and residual (after grazing) fescue-red clover pasture samples from Glade Spring are presented in table 6 . Data from Middleburg were deleted for the remaining chemical parameters due to small and imcomplete samples. Differences between grazing pressures of the residual forage were not large. Regrowth of the forage in early spring is demonstrated in lower cell wall contents in the residual as compared to the initial sampling in the February to April samplings.

Crude Protein and Lignin. The crude protein and lignin compositions of the initial and residual fescue-red clover pasture samples from Glade Spring are given in table 7 . Crude protein remained constant over the sampling dates during the winter, while lignin tended to increase as the winter progressed. Crude protein and lignin levels were higher in the residual samples from top grazing pastures than the whole plant grazing. All aftermath forages contained crude protein

TABLE 6 . CELL WALLS AND ACID DETERGENT FIBER OF INITIAL AND RESIDUAL TALL FESCUE-RED CLOVER PASTURES

Item	Component by pasture grazing dates					
	11-18-76 to 12-13-76		12-13-76 to 2-25-77		2-25-77 to 4-6-77	
	Cell walls	ADF[a]	Cell walls	ADF[a]	Cell walls	ADF[a]
	-%-	-%-	-%-	-%-	-%-	-%-
Top grazing[b]						
Initial[c]	51.8	31.4	61.1	35.5	69.2	41.8
Residual[d]	67.2	49.6	73.0	56.0	63.4	44.3
Difference	-15.4	-18.2	-11.9	-22.5	5.8	-2.5
Whole grazing[e]						
Initial[c]	49.3	29.8	62.6	37.3	66.3	40.6
Residual[d]	68.8	56.3	76.1	62.3	63.6	47.5
Difference	-19.5	-26.5	-13.5	-25.0	2.7	-6.9
Whole grazing[f]						
Initial[c]	50.9	29.9	61.6	34.5	64.7	44.5
Residual[d]	68.7	51.0	83.2	61.9	59.7	45.6
Difference	-17.8	-21.1	-21.6	-27.4	5.0	-1.1

[a]Acid detergent fiber.
[b]Systems 1, 2 and 6.
[c]Sampled prior to grazing.
[d]Sampled after grazing.
[e]Systems 3, 4 and 5.
[f]System 7.

TABLE 7 . CRUDE PROTEIN AND LIGNIN COMPOSITION OF INITIAL AND RESIDUAL TALL FESCUE-RED CLOVER PASTURES. GLADE SPRING

	Componet by pasture grazing dates					
	11-18-76 to 12-13-76		12-13-76 to 2-25-77		2-25-77 to 4-6-77	
Item	Crude protein	Lignin	Crude protein	Lignin	Crude protein	Lignin
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	16.9	5.7	16.8	7.2	15.6	8.3
Residual[c]	13.6	15.3	13.2	13.9	16.7	14.7
Difference	3.3	-9.6	3.6	-6.7	-1.1	-6.4
Whole grazing[d]						
Initial[b]	17.9	5.2	17.8	7.9	16.4	8.2
Residual[c]	13.0	12.7	10.8	12.1	12.7	13.5
Difference	4.9	-7.5	7.0	-4.2	3.7	-5.3
Whole grazing[e]						
Initial[b]	18.4	5.2	17.6	6.0	14.9	7.6
Residual[c]	12.0	10.6	11.0	10.6	17.2	17.8
Difference	6.4	-5.4	6.6	-4.6	-2.3	-10.2

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[e]System 7.

levels above 10.6%, indicating the forage contains adequate crude protein for residual grazing by dry beef cows.

Lignin levels were higher in residual top grazing than whole plant grazing samples. Greater quantities of winter burned residual material were present in top grazed plots, compared to the whole plant grazed pastures, which could explain these results. Archer and Decker (1977b) reported lignin and silica levels were higher in winter burned grass material. High lignin levels decrease nutrient availability in forages (Van Soest, 1965b). Low energy concentrations in forages are associated with decreases in voluntary intake (Blaxter et al., 1961). The implications of these data could explain why differences in rates of gain were not found between top and whole grazing systems with no grain supplementation. Forage availability was greater in top grazing systems but these effects were not reflected in increasing animal gains. Voluntary intake of the available forage could have been a factor.

Cellulose and Total Nonstructural Carbohydrates. Cellulose and total nonstructural carbohydrates of initial and residual fescue-red clover forage samples at Glade Spring are presented on table 8 . Cellulose and total nonstructural carbohydrates were lower in residual, compared to initial samples. Cellulose levels were generally higher in residual samples from top grazing systems. Cellulose levels in the initial samples increased during the winter. Cellulose decreased from initial to residual samples, indicating that much of the plant cellulose is located closely associated with the upper portions of the plant.

The digestibility of cellulose is dependent upon its association

TABLE 8 . CELLULOSE AND TOTAL NONSTRUCTURAL CARBOHYDRATES COMPOSITION OF INITIAL AND RESIDUAL TALL FESCUE-RED CLOVER PASTURES. GLADE SPRING.

Item	Component by pasture grazing dates					
	11-18-76 to 12-13-76		12-13-76 to 2-25-77		2-25-77 to 4-6-77	
	Cellulose	TNC[a]	Cellulose	TNC[a]	Cellulose	TNC[a]
	%	%	%	%	%	%
Top grazing[b]						
Initial[c]	24.8	11.5	26.6	7.7	25.1	3.5
Residual[d]	23.7	4.4	21.6	1.8	19.6	2.8
Difference	1.1	7.1	5.0	5.9	5.5	.7
Whole grazing[e]						
Initial[b]	23.6	10.7	26.2	6.5	25.2	4.0
Residual[c]	18.5	3.5	17.6	1.5	19.3	2.6
Difference	5.1	7.2	8.6	5.0	5.9	1.4
Whole grazing[f]						
Initial[b]	23.7	10.5	26.6	7.6	25.1	3.5
Residual[c]	21.6	5.8	16.8	1.7	19.8	3.5
Difference	2.1	4.7	9.8	5.9	5.3	0

[a]Total nonstructural carbohydrates.
[b]Systems 1, 2 and 6.
[c]Sampled prior to grazing.
[d]Sampled after grazing.
[e]Systems 3, 4 and 5.
[f]System 7.

with lignin (Van Soest, 1965a). Cellulose and lignin levels were high in top grazed residual forage samples possibly indicating a low digestibility of cellulose. Sheehan et al. (1978, unpublished data) found the dry matter of basal areas of fescue and orchardgrass during the late winter was more digestible (in vitro) than that of leaf tips. High levels of poorly digestible cellulose in the leaf areas of the plant could partially account for these findings. No differences in carbohydrate levels between top and whole grazing systems were found. Declines in total nonstructural carbohydrate levels between initial and residual sampling were confounded by losses in structural carbohydrates occurring during the winter due to winter burn. Forage palatability was reported to be correlated to total nonstructural carbohydrate levels (Bland and Dent, 1962).

In Vitro Dry Matter Digestibility and Kilograms of Digestible Dry Matter per Hectare. The in vitro digestibility and digestible dry matter per hectare for the initial and residual feacue-red clover pasture samples from Glade Spring and Middleburg, respectively, are shown in tables 9 and 10. Differences in the initial in vitro digestibility and digestible dry matter yields between grazing pressures were a function of pasture variation and were not influenced by treatment. Differences in initial and residual samples between grazing pressures are biased because of variations in the initial samples. The parameter which can be most closely controlled is the residual levels of components remaining after grazing.

TABLE 9. IN VITRO DRY MATTER DIGESTIBILITY AND DIGESTIBLE DRY MATTER PER HECTARE OF INITIAL AND RESIDUAL TALL FESCUE-RED CLOVER PASTURES AT GLADE SPRING

	In vitro dry matter digested by grazing date					
	11-18-76 to 12-13-76		12-13-76 to 2-25-77		2-25-77 to 4-6-77	
Item	Percent	Kg/ha	Percent	Kg/ha	Percent	Kg/ha
Top grazing[a]						
Initial[b]	68.4	3018	57.4	1265	49.1	1881
Residual[c]	43.9	505	26.9	639	48.1	521
Difference	24.5	2513	30.5	626	1.0	1360
Whole grazing[d]						
Initial[b]	69.6	2197	55.0	1459	49.8	1677
Residual[c]	33.4	174	23.4	330	42.0	205
Difference	36.2	2023	31.6	1129	7.8	1472
Whole grazing[d]						
Initial[b]	70.8	2962	60.8	1874	45.9	971
Residual[c]	39.6	346	24.8	477	46.4	259
Difference	31.2	2616	36.0	1397	-1.5	712

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[e]System 7.

TABLE 10. IN VITRO DRY MATTER DIGESTIBILITY AND DIGESTIBLE DRY MATTER PER HECTARE OF INITIAL AND RESIDUAL TALL FESCUE-RED CLOVER PASTURES AT MIDDLEBURG

	In vitro dry matter digested by grazing date			
	November 18 to late December		Late December to mid February	
Item	Percent	Kg/ha	Percent	Kg/ha
Top grazing[a]				
Initial[b]	73.5	2626	57.7	2332
Residual[c]	53.4	1348	44.7	558
Difference	20.1	1278	13.0	1774
Whole grazing[d]				
Initial[b]	75.1	3037	54.4	1651
Residual[c]	51.4	161	47.5	282
Difference	23.7	2876	6.9	1369
Whole grazing[e]				
Initial	71.9	2771	61.0	2596
Residual	50.0	261	50.1	869
Difference	21.9	2510	10.9	1727

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[e]System 7.

In vitro dry matter digestibility and kilograms of digestible dry matter remaining per hectare tended to be higher for top than whole plant grazers. Systems of top grazing were designed to allow more selective grazing by steers to insure more forage availability with consumed forage being of higher quality. Top grazing systems were designed for cattle with low production needs to graze behind top grazers to fully utilize the available forage. After top grazing, plots appear to have adequate forage of relatively high IVDMD to maintain dry beef cows.

Animal Gains. Average daily gains for steers on stockpiled fescue-red clover pastures at Glade Spring and Middleburg are presented in table 11. The most obvious differences in gains were that all steer groups at Middleburg gained at a faster rate than Glade Spring steers. Steers at Glade Spring were Angus X Hereford crosses bought at a local auction sale while Angus steers used at Middleburg were from the research station's herd. The winter at Glade Spring appeared to be more severe than at Middleburg, with heavy snow accumulation necessitating hay feeding for 65 days. Less snow at Middleburg required feeding only small amounts of hay. Yearling steers at Middleburg were much lighter than the Glade Spring yearlings.

No differences were found between top and whole grazing systems for calves without grain supplementation at either location (.40 kg per day for Glade Spring and .63 kg per day for Middleburg). Perhaps the similar performance is attrubutable to the higher digestibility of dry matter in the basal portion than the leaf tips (Sheehan *et al.*,

TABLE 11. DAILY GAINS OF FORAGE FINISHING STEERS ON STOCKPILED FESCUE-RED CLOVER PASTURES AT TWO VIRGINIA LOCATIONS

System	1	2	3	4	5	6	7
Kind of steers	Weanlings				Yearlings		
Type of grazing	Top		Whole		Whole	Top	Whole
Grain level, % of bodywt.	0	.5	0	.5	.5	0	1.0
	kg	kg	kg	kg	kg	kg	kg
Glade Spring							
Initial weight	234.00	234.00	234.00	239.00	330.00	329.00	326.00
Daily gain							
0-56 days	.20	.55	.27	.40	.33	.15	.29
57-112 days	.50	.41	.38	.59	.82	.55	.82
113-154 days	.55	1.00	.60	.63	.54	.55	.94
0-154 days	$.40^{b}$	$.61^{c}$	$.40^{b}$	$.52^{b,c}$	$.56^{c}$	$.40^{c}$	$.76^{d}$
Middleburg							
Initial weight	264.00	256.00	254.00	257.00	270.00	263.00	262.00
Daily gain							
0-56 days	.68	1.04	.65	.59	.86	1.00	1.05
57-112 days	.70	.74	.79	.59	.92	.85	.88
113-154 days	.47	.86	.39	.62	.60	.52	.80
0-154 days	$.63^{b}$	$.88^{c}$	$.63^{b}$	$.60^{b}$	$.80^{b}$	$.81^{b}$	$.92^{b}$

[a]Differences between gains of calves and yearlings were not tested statistically.

[b,c,d]Means on the same line within age of cattle (weanlings and yearlings) with different superscript letters are different ($P < .05$).

1978, unpublished data). Calves on top grazing systems fed grain at .5% of bodyweight gained faster ($P < .05$) than calves on systems with whole plant grazing with .5% grain. Daily gains during the 154 day wintering trial for the top and whole plant grazing calves receiving .5% grain were .61 and .52 kg for Glade Spring and .88 and .60 kg for Middleburg, respectively. Gains of the whole plant grazers with .5% grain at Middleburg were low.

Calf gains at Glade Spring and Middleburg receiving no grain supplementation with either top or whole plant grazing were similar. These results indicate that plant quality does not change greatly from leaf tip to base. It is possible that plant quality is actually higher in the basal areas of the plant than in the leaf tips during the winter. Taylor and Templeton (1976) reported winter burned leaf tips were lower in total nonstructural carbohydrates and higher in cell wall content, lignin and silica than the greener basal portions of the plant.

Gains for yearling steers at Glade Spring were highest ($P < .05$) for those fed the highest level of grain. Yearling steers at Middleburg with 1.0% grain and whole plant grazing gained .92 kg over the 154 day wintering trial, which tended to be higher than either top grazing with no grain or whole grazing with .5% grain (.81 and .80 kg).

The higher rates of gain for cattle at Middleburg may be partially due to forage availability. Availability and digestibility of forage appeared to be higher in steers at Middleburg than at Glade Spring. More orchardgrass was present in the Glade Spring pastures. Dry matter intake and performance have been reported to be higher for cattle grazing stockpiled fescue than for those grazing orchardgrass (Baker et al., 1965). Blaxter et al. (1961) reported a 10 percentage unit increase in digestibility within the range of 40 to 60% would increase gains by 100%. Small differences in in vitro digestibility along with more forage availability could explain differences in steer weight changes between locations.

The comparison of top grazing and whole grazing, especially at Glade Spring, was not entirely valid because steers were receiving hay much of the winter. However, top grazing did not seem practical when based on kilograms of beef produced per hectare.

Higher rates of gain were found for top grazers receiving .5% compared to whole plant grazers receiving .5% grain. Corbett et al. (1963) found small increases in ration digestibility increased voluntary intake and rate of gain. Grain supplementation would increase overall ration digestibility and could explain differences in rates of gain.

Steers receiving 1.0% of bodyweight grain supplement gained more rapidly than any other treatment. Steers in this system were slaughtered in May with a rapid rate of gain necessary for market weight and grade.

Evaluation of Forage-Animal Management Systems-Summer

Ambient climatic conditions were very different between research stations. The Glade Spring station received ample rainfall in early spring followed by 3 to 4 weeks of dry weather. Above normal precipitation was recorded in summer and early fall. The Middleburg research station in northern Virginia encountered extreme drought during most of the summer. Yields of bluegrass-legume mixtures were low, hence steers grazed primarily fescue-red clover pastures until early August as orchardgrass-alfalfa fields were harvested for hay. Rainfall in late summer allowed grazing of bluegrass-white clover and orchardgrass-alfalfa.

Chemical Parameters

Table 12 shows the type and number of grass-legume pastures grazed during the spring to fall season. Grass-legume mixtures being grazed may affect subsequent animal gains. Blaser et al. (1956) reported steer gains to be lower on fescue-white clover pastures than either orchardgrass or bluegrass white clover. Owen et al. (1976) found rate of eating, time spent eating and kilograms of dry matter consumed were lower for cattle fed fescue, compared to those fed fresh orchardgrass.

Estimated legume content in pastures grazed during spring to fall are given in table 13. Legume components in pastures are important as rates of gain were higher for steers grazing grass-legume pastures, compared to nitrogen fertilized grass pastures (Blaser et al., 1960). Cowlishaw and Adler (1960) reported that cattle consume mixtures of grasses and legumes more readily than pure stands of either herbage.

Cell Wall Contents. Cell wall contents for forage samples harvested at two Virginia locations are presented in table 14. Percent cell walls tended to be higher for whole grazing residual compared to samples. Cell wall contents increased from early spring to summer. Van Soest (1965a) reported that cell solubles and cell walls accounted for 96%

TABLE 12. KIND AND NUMBERS OF PASTURES GRAZED BY GROWING-FINISHING STEERS AT TWO VIRGINIA LOCATIONS

Kind of pasture	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
Top grazing[a]						
Fescue-red clover			1	4	2	2
Bluegrass-white clover	2	4			3	7
Orchardgrass-alfalfa	2		2		1	6
Whole grazing[b]						
Fescue-red clover		1	2		1	3
Bluegrass-white clover	2	2		4	3	3
Orchardgrass-alfalfa	2		1		1	6
Whole grazing[c]						
Fescue-red clover	2	2				

[a]Systems 1, 2 and 6.
[b]Systems 3, 4 and 5.
[c]System 7.

TABLE 13. ESTIMATED LEGUME CONTENT OF PASTURES GRAZED BY GROWING-FINISHING STEERS AT TWO VIRGINIA LOCATIONS

	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
Legume Component	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Red clover						
Initial[b]			57	42	44	38
Residual[c]			42	21	42	17
White clover						
Initial[b]	55	24			46	13
Residual[c]	43	16			24	11
Alfalfa						
Initial[b]	76		77		40	78
Residual[c]	70		43		28	63
Whole grazing[d]						
Red clover						
Initial[b]			26	47	23	36
Residual[c]			12	27	2	18
White clover						
Initial[b]	48	24			28	5
Residual[c]	46	7			22	7
Alfalfa						
Initial[b]	48		68		58	86
Residual[c]	46		52		56	87
Whole grazing[f]						
Red clover						
Initial[b]	17	32				
Residual[c]	28	28				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[f]System 7.

TABLE 14. CELL WALL CONTENTS OF INITIAL AND RESIDUAL SAMPLES FROM SPRING, SPRING-SUMMER AND SUMMER-FALL PASTURES

	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
Item	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	38.5	46.8	57.2	58.2	63.6	52.8
Residual[c]	51.1	59.1	70.3	62.3	65.5	61.7
Differences	-12.6	-12.3	-13.1	-4.1	-2.9	-8.9
Whole grazing[d]						
Initial[b]	44.0	52.6	58.3	53.3	63.9	50.7
Residual[c]	59.5	65.7	71.3	65.8	68.0	63.8
Differences	-15.5	-13.1	-13.0	-12.5	-4.1	-13.1
Whole grazing[e]						
Initial[b]	48.9	54.2				
Residual[c]	54.9	67.0				
Differences	-6.0	-12.8				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[e]System 7.

of the variation in in vitro dry matter digestiblity. Van Soest further suggested that cell wall contents above 50 to 60% inhibit intake of forage due to a large fiber mass in the rumen. Balch (1950) found that ration digestibility was inversely related to retention times in the digestive tract. Blaxter et al. (1961) reported voluntary intake of mature wethers increased rapidly as feed digestibility increased from 38 to 70%.

Corbett et al. (1963) reported organic matter intake decreased 20% as organic matter digestibility of forages declined from 80 to 63%. The decrease in forage digestibility was accompanied by increases in fiber level.

Acid Detergent Fiber. Acid detergent fiber levels tended to increase from early spring to summer (table 15), and tended to be lower in residual samples from top grazing than whole grazing systems. Allison (1971) found increasing temperatures decreased in vitro dry matter and cellulose digestibility. Acid detergent fiber levels increased with increasing light intensities and daylength. Hemicellulose levels increased with increasing daylength and temperature. Yu and Thomas (1976) reported acid detergent fiber to be most closely, and negatively, related to in vivo alfalfa hay digestibility. The acid detergent fiber component is similar to but lower than the cell wall content, with only the hemicellulose fraction not present.

Crude Protein. Crude protein contents of forages presented in table 16 were adequate for growing-finishing steers. All grazing paddocks contained mixtures of grasses and legumes. Crude protein

TABLE 15. ACID DETERGENT FIBER CONTENT OF INITIAL AND RESIDUAL SAMPLES FROM SPRING, SPRING-SUMMER, AND SUMMER-FALL PASTURES

Item	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	28.1	27.7	35.6	35.0	38.6	35.2
Residual[c]	36.1	33.0	44.4	40.1	40.7	41.7
Differences	-8.0	-5.3	-8.8	-5.1	-2.1	-6.5
Whole grazing[d]						
Initial[b]	28.7	32.7	36.8	33.0	38.8	34.7
Residual[c]	39.6	41.3	44.0	42.0	40.1	45.9
Differences	-10.9	-8.6	-7.2	-9.9	-1.3	-11.2
Whole grazing[e]						
Initial[b]	26.8	33.3				
Residual[c]	33.4	41.9				
Differences	-6.6	-8.6				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]System 3, 4 and 5.
[e]System 7.

TABLE 16. CRUDE PROTEIN CONTENT OF INITIAL AND RESIDUAL SAMPLES FROM SPRING, SPRING-SUMMER, AND SUMMER-FALL PASTURES

Item	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	22.4	21.5	15.0	17.2	16.0	16.0
Residual[c]	17.5	14.7	16.2	13.6	15.3	15.7
Difference	4.9	6.8	-1.2	3.6	.7	.3
Whole grazing[d]						
Initial[b]	21.8	22.2	15.6	16.4	15.8	19.0
Residual[c]	16.1	11.6	14.1	12.1	15.4	15.2
Difference	5.7	10.6	1.5	4.3	.4	3.8
Whole grazing[e]						
Initial[b]	25.8	15.0				
Residual[c]	19.7	11.4				
Difference	6.1	3.6				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[e]System 7.

levels tended to be higher in spring than the summer forages. Vough and Marten (1971) reported high temperatures decreased yield and digestibility of forages but did not alter crude protein content. Blaser (1964) concluded that forages with higher percentages of leaves are higher in crude protein and digestibility. Bowman and Law (1964) found relative leaf percentage increased as temperature increased from 17 to 27 C.

Total Nonstructural Carbohydrates. The total nonstructural carbohydrate contents of initial and residual forage samples are given in table 17. Carbohydrate levels in residual samples were not different between grazing pressures. Carbohydrate levels were lower in summer pastures than winter pastures. Fescue was the major forage present in wintering studies. Total nonstructural carbohydrate levels did not show consistent trends during the summer grazing period.

Legumes store nonstructural carbohydrates as strach which is only partially extractable by the carbohydrate analysis used in this study (Wolf and Ellmore, 1973). Increasing relative legume levels in pastures would decrease carbohydrate levels slightly. Smith and Jewiss (1966) found nonstructural carbohydrate levels to be lower when temperatures increased from 18.5 to 29.5 C. Smith (1977) found that levels increased with increased forage production. Interpretations of nonstructural carbohydrate data should include daily sampling time since Lechtenberg et al. (1971) found that carbohydrate levels are much higher in late afternoon than early morning with intermediate values between these times.

TABLE 17. TOTAL NONSTRUCTURAL CARBOHYDRATES OF INITIAL AND RESIDUAL SAMPLES FROM SPRING, SPRING-SUMMER, AND SUMMER-FALL PASTURES

Item	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	5.6	8.9	5.4	4.7	3.6	5.4
Residual[c]	5.2	10.7	2.7	4.5	4.5	4.9
Differences	.4	-1.8	2.7	.2	-.9	.5
Whole grazing[d]						
Initial[b]	5.9	6.6	6.4	6.0	3.4	4.6
Residual[c]	5.4	6.6	3.7	5.5	3.9	5.8
Differences	.5	0	2.7	.5	-.5	-1.2
Whole grazing[e]						
Initial[b]	9.2	8.4				
Residual[c]	5.7	6.7				
Differences	3.5	1.7				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]System 3, 4 and 5.
[e]System 7.

Cellulose and Lignin. Cellulose and lignin levels (tables 18 and 19, respectively) increased from spring to summer. Cellulose and lignin levels were generally higher in the residual than the initial forage for both grazing pressures. Cellulose represents a major structural polysaccharide of plant fiber with its digestibility somewhat dependent on lignin (Van Soest, 1965b). Wilson et al. (1976) found higher termperatures decreased in vitro digestibility in fully expanded leaves without increasing cell wall contents. Lignin levels were increased in the summer in the present study. Perhaps encrustation by lignin on structural polysaccharides depressed fiber availability.

Sullivan et al. (1956) reported that lignin levels vary between grass species, with fescue containing medium levels, orchardgrass medium to high and bluegrass high levels. Sosulski et al. (1960) found lignin levels to be 5.3, 7.8 and 8.9% for leaves, stems and seed heads, respectively. Rate of plant lignification was most rapid from preheading to heading. Silica or lignin levels divided by either cell wall contents or acid detergent fiber were the combination of factors most closely related to cell wall content digestiblity (Archer and Decker, 1977a). Van Soest and James (1968) reported for each percentage unit increase in silica there was a three percentage unit decrease in in vitro digestibility. These workers postulated silica acts similarly to lignin and may be assoicated with lignin, acting to encrust structural polysaccharides, thereby lowering their digestibility.

TABLE 18. CELLULOSE CONTENT OF INITIAL AND RESIDUAL SAMPLES FROM SPRING, SPRING-SUMMER, AND SUMMER-FALL PASTURES

Item	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	22.3	19.5	27.1	24.5	28.2	22.7
Residual[c]	29.3	22.9	30.4	28.0	29.3	24.9
Differences	-7.0	-3.4	-3.3	-3.5	-1.1	-2.2
Whole grazing[d]						
Initial[b]	22.7	22.3	26.0	23.5	27.9	23.1
Residual[c]	28.9	25.1	27.3	27.8	28.9	26.4
Differences	-6.2	-2.8	-1.3	-4.3	-1.0	-3.3
Whole grazing[e]						
Initial[b]	18.0	25.0				
Residual[c]	20.8	31.2				
Differences	-2.8	-6.2				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]System 3, 4 and 5.
[e]System 7.

TABLE 19. LIGNIN CONTENT OF INITIAL AND RESIDUAL SAMPLES FROM SPRING, SPRING-SUMMER, AND SUMMER-FALL PASTURES

Item	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	4.8	4.7	7.7	10.2	8.4	9.3
Residual[c]	6.2	4.7	9.3	11.1	8.5	10.8
Differences	-1.4	0	-1.6	-.9	-.1	-1.5
Whole grazing[d]						
Initial[b]	4.8	7.1	5.8	9.4	8.9	9.3
Residual[c]	6.7	7.4	8.6	10.8	8.5	12.2
Differences	-1.9	-.3	-2.8	-1.4	.4	-2.9
Whole grazing[e]						
Initial[b]	4.7	7.6				
Residual[c]	4.5	8.7				
Differences	.2	-1.1				

[a]Systems 1, 2 and 6.
[b]Sampled prior to grazing.
[c]Sampled after grazing.
[d]Systems 3, 4 and 5.
[e]System 7.

In Vitro Dry Matter Digestibility. In vitro digestibility data for initial and residual samples by period at Glade Spring and Middleburg are given in table 20. Digestibility of residual samples was usually higher for top grazing systems. Pasture digestibility tended to decrease from spring to fall. Deinum et al. (1968) reported that increasing photoperiod and temperature increased cell wall content and decreased in vitro digestibility. Smith (1969) compared warm (32/24 C) and cool (18/10 C) day/night temperature regimes in a growth chamber study. Warm temperatures increased plant maturation rate and decreased digestibility. Wilson et al. (1976) found higher temperatures decreased in vitro digestibility of recently expanded leaves with an increase digestibility of fully expanded leaves, but cell wall contents did not increase. Lignin levels increased in fully expanded leaves, and the authors speculated lower fiber availability in the plant due to lignin encrustation. Baile and Forbes (1974) reported voluntary intake of most forages was positively related to digestibility. Reid et al. (1978) found a correlation coefficient relating intake to dry matter digestibility of .39 for fresh ryegrass, bromegrass, orchardgrass and fescue of different qualities.

Animal Gains

Daily gains and carcass quality grades of steers grazing spring to fall pastures at Middleburg and Glade Spring are presented in tables 21 and 22, respectively. Gains tended to be higher in Glade Spring than Middleburg during the spring to fall grazing period. Higher gains

TABLE 20. IN VITRO DRY MATTER DIGESTIBILITY OF INITIAL AND RESDIUAL SAMPLES FROM SPRING-SUMMER, AND SUMMER-FALL PASTURES

Item	Location by grazing period					
	4-22-77 to 5-19-77		5-20-77 to 7-14-77		7-15-77 to 10-18-77	
	Glade Spring	Middleburg	Glade Spring	Middleburg	Glade Spring	Middleburg
	%	%	%	%	%	%
Top grazing[a]						
Initial[b]	73.2	70.9	67.6	63.3	66.2	57.8
Residual[c]	66.5	63.2	55.6	50.2	53.1	48.7
Difference	6.7	7.7	12.0	13.1	13.1	9.1
Whole grazing[d]						
Initial[b]	71.4	68.9	69.8	61.4	61.9	58.5
Residual[c]	60.6	54.1	57.5	54.2	50.7	45.8
Difference	10.8	14.8	12.3	7.2	11.2	12.7
Whole grazing[e]						
Initial[b]	69.5	68.5				
Residual[c]	61.5	57.7				
Difference	8.0	10.8				

[a] Systems 1, 2 and 6.
[b] Sampled prior to grazing.
[c] Sampled after grazing.
[d] Systems 3, 4 and 5.
[e] System 7.

TABLE 21. DAILY GAINS OF FORAGE FINISHING STEERS. MIDDLEBURG

System	1	2	3	4	5	6	7
Kind of steers	Weanling calves				Yearlings		
Type of grazing	Top		Whole		Whole	Top	Whole
Grain level, % of bodywt.	0	.5	0	1.0	1.0	0	1.0
	kg	kg	kg	kg	kg	kg	kg
Initial weight	361	391	351	349	388	392	403
155-182 days	.67	1.02	1.30	1.02	1.33	1.07	1.06
183-238 days	.52	.82	.54	.88	.92	.60	
239-332 days	.50	.44	.28	.60			
Summer period	.55	.68	.56	.78	1.07[a]	.78[a]	1.06[b]
Slaughter grade[c]	10.5[d]	12.0	10.2[d]	11.6	10.1	8.0	10.2

[a]Data for 155 to 238 days.
[b]Data for 155 to 182 days.
[c]Slaughter grades of 8 = high standard, 10 = average good, 11 = high good and 12 = low choice.
[d]One-half the steers were put in drylot and finished on corn silage and protein supplement.

TABLE 22. DAILY GAINS OF FORAGE FINISHING STEERS. GLADE SPRING

System	1	2	3	4	5	6	7
Kind of steers	Weanling calves				Yearlings		
Type of grazing	Top		Whole		Whole	Top	Whole
Grain level, % of bodywt.	0	.5	0	1.0	1.0	0	1.0
	kg	kg	kg	kg	kg	kg	kg
Initial weight	296	330	296	320	417	391	445
155-182 days	1.35	1.25	1.12	1.40	1.04	1.15	1.04
183-238 days	.89	.88	.93	.89	1.06	1.15	
239-332 days	.74	.50	.55	.69			
Summer period	.89	.74	.85	.87	1.05[a]	1.15[a]	1.04[b]
Carcass grade[c]	11.0[d]	11.6	10.2[d]	10.9	10.1	9.3	11.2

[a]Data for 155 to 238 days.
[b]Data for 155 to 182 days.
[c]Slaughter grades of 9 = low good, 10 = average good and 11 = high good.
[d]One-half the steers were put in drylot and finished on corn silage and protein supplement.

during this period can be explained at least in part by compensatory gains of steers at Glade Spring. Weight gains at Glade Spring the previous winter had been lower apparently due to adverse weather conditions. In vitro dry matter digestibility data suggest pasture quality during the summer was higher in Glade Spring than Middleburg, which had been under drought conditions during the summer, with pastures generally short and stunted. Baldwin et al. (1961) reported small increases in ration digestibility greatly increased average daily gains of mature wethers. Slightly higher digestibilities of forage at Glade Spring plus more available forage could account for increased weight gains.

Weanling calf gains at Middleburg were related to level of grain supplementation. The daily gains were .55, .56, .68 and .78 kg for steers receiving grain at 0, 0, 15 and 1% of bodyweight, respectively. Average gains at Glade Spring were slightly higher for calves receiving no grain, compared to those fed grain at .5 and 1% of bodyweight.

Yearlings at Middleburg receiving grain supplement and whole plant grazing gained faster than steers top grazing with no grain. Gains for yearling steers at Glade Spring were 1.15 kg for top grazers receiving no grain and 1.05 kg for whole plant grazers plus grain at 1% of bodyweight. Steer gains at Middleburg agreed with results presented by Wise et al. (1967) and Mott et al. (1971) who showed supplementing grain levels up to 1% of bodyweight increased gains of steers on pasture. Steer gains at Glade Spring were not increased with grain supplementation indicating that pasture quality and availability were adequate to support satisfactory weight gains. Perhaps the difference in response to grain supplementation between locations was related to the kinds of forage grazed. At Glade Spring the cattle sequence grazed high quality forages from bluegrass-white clover, fescue-red clover and orchardgrass-alfalfa pastures. At Middleburg steers grazed fescue-red clover during much of the summer due to limited forage growth caused by drought conditions. Blaser et al. (1956, 1960) reported gains were lower for steers grazing fescue-legume mixtures compared to either orchardgrass-legume or bluegrass-legume pastures. Mott et al. (1971) reported gains of steers grazing fescue were low due to an inadequate energy intake. Decreased intake of digestible organic matter can greatly reduce liveweight gains (Corbett et al., 1963).

Carcass grades of weanling calves were similar for Middleburg and Glade Spring. Whole grazers with no grain supplement had the lowest carcass grades while top grazers with .5% grain supplement had the highest. Yearling steers at Glade Spring had slightly higher carcass grades than those at Middleburg, probably a result of the higher initial weights for steers used at Glade Spring.

Finished steers of average to high good were produced in system 7 in May after grazing stockpiled fescue-red clover pastures. The production of finished steers off pasture and grain at this time allows an alternative system for producing steers at more times during the year.

Nutrient Digestibility and Palatability of Fescue

Average plant heights and stages of growth for fescue forage at the midpoint of the palatability trial, which generally coincided with the forage harvesting date for the metabolism trial, are shown in table 23. The fescue forage used in May was becoming reproductive during the 10-day measurement period of the palatability trial, and changed from the boot to early head stage. Fescue forage harvested in the July trial was yellowish in color, due to nitrogen deficiency or dry weather.

Fescue was still green in November. The palatability trial and forage harvesting for the metabolism trial was completed prior to any significant snow accumulation. The forage fluctuated dramatically in moisture content between days because of very wet weather. Measurable precipitation was recorded on 12 of 17 forage harvesting days for the palatability trial. February fescue was brown in color due to severe winter burn, and the only green material present was the basal portion of the plant. This section of the plant had been protected from the severe winter weather by the matted leaf tips. The forage was indicated to be in the vegetative stage of growth, but was actually in a dormant stage. The 1977-78 winter was very cold, being accompanied by heavy snow accumulations. The forage was completely covered by snow most of the winter until early February.

Deterioration in the quality of stockpiled fescue is evident in the evaluation of the chemical components in November and February fescue (table 24). Crude protein content remained fairly constant

TABLE 23. AVERAGE PLANT HEIGHTS AND STAGE OF GROWTH FOR FRESH FESCUE FORAGE HARVESTED AT FOUR DIFFERENT TIMES

Date	Plant height[a]	Stage of growth
	cm	
May 17, 1977	57	Late boot
July 27, 1977	19	Vegetative
November 15, 1977	48	Vegetative
March 2, 1978	42	Vegetative

[a]Each value represents a mean of 45 determinations.

TABLE 24. COMPOSITION OF FESCUE FORAGE HARVESTED AT FOUR DIFFERENT TIMES

Component	Harvest time			
	May 23, 1977	August 1, 1977	November 16, 1977	March 4, 1978
Dry matter, %				
Composition of dry matter, %				
Crude protein	10.4	10.3	10.6	9.5
Crude fiber	33.7	32.2	31.0	37.7
Ether extract	3.0	4.4	2.9	2.8
Nitrogen-free extract	45.9	42.8	47.8	39.5
Ash	7.1	10.3	7.7	10.5
Total nonstructural carbohydrates	13.9	9.9	15.9	5.5
Cell walls	65.6	63.3	59.8	72.6
Acid detergent fiber	36.0	38.3	35.0	39.9
Cellulose	29.5	27.7	27.5	29.6
Hemicellulose	29.6	25.0	24.8	32.8
Lignin	6.3	7.8	7.6	7.3
Residual Ash	.5	2.8	1.3	2.9

while total nonstructural carbohydrate levels dropped from 15.9 to 5.5% from November to February, respectively. This drop in total nonstructural carbohydrate content was accompanied by an increase in most of the fibrous components of the forage. Winter burn causes a loss in the most readily available nutrient, such as total nonstructural carbohydrates, due to freezing temperatures causing the plant cells to rupture. This loss of nutrients results in a plant of lower nutritive value. Balasko (1977) reported decreases in yield, IVDMD and total nonstructural carbohydrate levels with increases in the fibrous components with stockpiled fescue from December to January in West Virginia.

Apparent Digestibility of Fescue

Apparent digestion coefficients for several components of fescue harvested in May, August, November and March are presented in table 25 . Apparent digestibility of dry matter, organic matter and crude protein was higher ($P < .05$) in May than in August forage. Values from November fescue were intermediate, but not significantly different from May or August harvested forage. Apparent digestibility of these components was lowest ($P < .05$) for the March dried fescue forage. The decline in digestibility of dried fescue in March compared to November was accompanied by a large decline in nutrient quality of the forage. The significantly higher digestibility of fescue harvested in May compared to August shows the high quality of fescue in spring. Reid *et al*. (1966) and Deinum *et al*. (1968) reported dry matter digestibility to be higher in spring than summer forage. Deinum *et al*. further reported

TABLE 25. DIGESTIBILITY OF FESCUE FORAGE HARVESTED AT FOUR DIFFERENT TIMES

Component	Apparent digestibility at different times of harvest			
	May, 1977	August, 1977	November, 1977	March, 1978
Dry matter	67.5^{a}	57.4^{b}	63.3^{a,b}	42.7^{c}
Organic matter	67.1^{a}	59.0^{b}	63.6^{a,b}	44.3^{c}
Crude protein	65.0^{a}	59.9^{b}	62.4^{a,b}	37.1^{c}
Cell walls	67.9^{a}	57.1^{b}	59.8^{b}	45.1^{c}
Acid detergent fiber	63.1^{a}	52.4^{b}	54.0^{b}	39.4^{c}
Cellulose	68.7^{a}	63.6^{a}	64.6^{a}	51.8^{b}
Hemicellulose	73.6^{a}	64.5^{b}	67.5^{b}	52.9^{c}
Lignin	45.1^{a}	35.6^{a}	23.5^{b}	13.4^{b}

^{a,b,c}Means on the same line with different superscript letters are different ($P<.05$).

that a 10 percentage unit decrease in in vitro dry matter digestibility from spring to summer was due to increasing day length and temperature, which increased cell wall contents. Wilson et al. (1976) also found high temperatures increased cell wall contents and decreased in vitro digestibility in recently expanded leaves. Further, cell wall contents were not increased with prolonged periods of high temperature after initial increases, but in vitro dry matter digestibility demonstrated further depressions. They postulated that lignin encrustation of the fibrous components resulted in decreased availability of the cell wall components which lowered in vitro digestibility. Bowman and Law (1964) and Vough and Martin (1971) also reported high tempertures decreased in vitro dry matter digestibility, while increasing the leaf to stem ratio of grasses. High temperatures tend to accelerate the rate of plant maturity, increasing the relative amounts of fibrous to non-fibrous components at an earlier plant stage (Smith, 1969).

Digestibilities of cell wall contents, acid detergent fiber and hemicellulose were highest ($P < .05$) in May and lowest in March fescue. Cellulose digestibility was similar for May, August and November harvested forage, with values being lower ($P < .05$) for the March fescue. The digestibility values for the forage component analyzed to be lignin was substantial at all times. May and August dried forages were higher ($P < .05$) in lignin digestibility than those for the November and March forage. The relatively high digestibilities of lignin in all four forage sources is surprising. Lignin is generally considered an indigestible fibrous portion of the plant which adds rigidity (Crampton and Harris, 1969). In the present study, May harvested fescue had a lignin digestibility of 45%. Guardiola et al. (1978) and Weiss et al. (1978) reported digestibilities of 35 to 40 percent for lignin in first-cut fescue hay.

Digestibility of all fibrous components, except lignin, tended to be lower in August than either May or November harvested forages. Allison (1971) found lower ambient temperatures were associated with increased digestibility of the fibrous components. Bush et al. (1976) reported alkaloid content of fescue is involved in depressing the activity of cellulolytic bacteria.

The residual ash components of harvested fescue were reported because large variations between replicates in silica determination made statistical analysis of the values impractical. Residual ash values in this study were negatively related to most digestibility parameters. Silica is a major component of residual ash values (Sheehan et al., 1978, unpublished results). Bailey (1976) reported silica was largely indigestible when fed as a component of hay. Van Soest and Jones (1968) reported a 1 percentage unit increase in silica decrease in vitro dry matter digestibility by 3 percentage units. These researchers hypothesized that silica acts similarly to lignin and may be associated with lignin while encrusting cell wall carbohydrates and decreasing their availability for digestion.

The deterioration of fescue over the winter with respect to quality of the forage was indicated by a browning of the February harvested forage. Archer and Decker (1977b) found digestibility decreased with increasing levels of dead material. Silica levels were 1.0 and 4.3% for green leaves and dead leaf tips, respectively. They (Archer and Decker, 1977c) found fiber digestibility decreased with increasing ratios of silica or lignin to cell walls or acid detergent fiber levels. These researchers also speculated silica may reduce cell wall content availability by processes of encrustation.

Nitrogen Balance. Daily nitrogen balance data of wethers fed dried fescue forage are given in table 26. Dried fescue forage from March contained more moisture than forage harvested at other times. All forages were fed at the same level on an air dry basis with a smaller amount of dry matter being fed of the March forage. March harvested forage was slightly lower in crude protein content. These two factors resulted in a lower daily nitrogen intake for sheep fed this forage. Daily fecal nitrogen excretion was higher ($P< .05$) in sheep fed March fescue, although the nitrogen intake was lowest for sheep fed this forage, reflecting the lower digestibilility of crude protein (table 25). No significant differences were found between May, August and November forages. Uninary nitrogen losses of sheep fed March harvested fescue were lower ($P <.05$) than sheep on other forage rations, probably a reflection of low levels of absorbed nitrogen. Nitrogen retention, expressed as grams per day, was lowest ($P <.05$) for sheep fed March fescue, but differences between sheep fed the other harvested forages were not significant. Negative retention values were observed only for sheep fed March dried fescue forage.

TABLE 26. DAILY NITROGEN BALANCE OF WETHERS FED FESCUE FORAGE HARVESTED AT FOUR DIFFERENT TIMES

Harvest time	N intake, g/day	N excretion, g/day		N retention		
		Feces	Urine	g/day	Percent of intake	Percent of absorbed
May, 1977	11.2	3.9^{a}	6.9^{a}	$.36^{a}$	3.3	4.9
August, 1977	11.2	4.5^{a}	6.5^{a}	$.19^{a}$	1.7	2.8
November, 1977	11.6	4.4^{a}	6.7^{a}	$.60^{a}$	5.2	8.3
March, 1978	9.1	5.7^{b}	6.0^{b}	-2.70^{b}	c	c

[a,b]Means in the same column with different superscript letters are different ($P<.05$).
[c]Were not calculated because retention values were negative.

Rumen Fluid Components. Ruminal fluid pH and ammonia nitrogen for sheep fed dried fescue forage are found in table 27. Rumen fluid pH was significantly higher for sheep fed the March fescue, probably due to a combination of low nutrient availability, high fiber content and slower turnover time in the rumen.

Rumen ammonia levels were higher ($P < .05$) for wethers receiving May or November fescue compared to August and February forage. Higher rumen levels occurred in sheep fed herbage which was higher in apparent digestibilities of crude protein and organic matter. These higher levels of rumen ammonia may be attributable to a more thorough and active degradation of nitrogen sources in the rumen. The fibrous nature of March fescue accompanied by depressed digestibilities of most nutrient parameters examined would probably reduce ruminal activity.

Total ruminal volatile fatty acids, expressed as μ moles per milliliter, were lowest ($P < .05$) in sheep fed March fescue (table 28). The value tended to be lower in sheep fed the August than those fed May fescue (95.88 vs. 103.21 μ moles per milliliter, respectively). The highest value was for sheep fed the November fescue. Total acetic and propionic acid levels were lowest ($P < .05$) in sheep fed March fescue. Total propionate levels were highest for sheep fed November dried forage but the differences were significant only when compared to the August and March forages. Total butyrate levels were lower ($P < .05$) for sheep fed August and March forage, compared to those fed May and November forage.

TABLE 27. RUMINAL FLUID pH AND AMMONIA NITROGEN OF SHEEP FED DRIED FESCUE FORAGE CUT AT FOUR DIFFERENT TIMES

	Harvest time			
Item	May, 1977	August, 1977	November, 1977	March, 1978
pH	6.82[a]	6.71[a]	6.83[a]	7.15[b]
NH_3-N, mg/100 ml	15.42[a]	12.74[b]	14.96[a]	12.74[b]

[a,b]Means on the same row with different superscript letters are different ($P < .05$).

TABLE 28. RUMINAL FLUID VOLATILE FATTY ACID CONCENTRATIONS OF SHEEP FED DRIED FESCUE FORAGE CUT AT FOUR DIFFERENT TIMES

Item	Harvest time			
	May, 1977	August, 1977	November, 1977	March, 1978
Volatile fatty acids, μmoles/ml				
Acetic	64.26^{a}	65.65^{a}	67.28^{a}	36.63^{b}
Propionic	28.69^{a}	22.75^{b}	34.36^{a}	21.59^{b}
Butyric	8.37^{a}	5.66^{b}	8.30^{a}	4.38^{b}
Isobutyric	.86	.76	.84	.60
Valeric	.36	.52	.47	.57
Isovaleric	.75	.54	.50	.59
Total	103.21^{a}	95.88^{a}	111.75^{a}	64.41^{b}
Volatile fatty acids, moles/100 moles				
Acetic	60.75^{a}	68.39^{b}	60.01^{a}	55.29^{a}
Propionic	28.91^{a,b}	23.80^{a}	30.66^{a,b}	34.57^{b}
Butyric	8.41^{a}	5.92^{b}	7.65^{a}	7.17^{a}
Isobutyric	.84	.79	.71	.98
Valeric	.40	.52	.46	.88
Isovaleric	.76	.54	.50	1.10

^{a,b} Means on the same line with different superscript letters are different ($P<.05$).

Acetic acid, expressed as moles per 100 moles, was highest for sheep fed August fescue. Propionate and butyrate were lower for sheep fed August forage, but differences were not always significant. Acetate to propionate ratios were lowest for sheep fed the March (1.60 to 1), followed by November (1.96 to 1), May (2.10 to 1) and August (2.90 to 1) forages. The high total and relative levels of propionate in stockpiled November fescues reflects the higher total nonstructural carbohydrates (table 24) and would appear to make this an excellent forage for finishing beef steers.

Palatability of Fescue

Table 29 shows several nutrient parameters in the alfalfa reference hay. Voluntary intakes of fescue forage and alfalfa hay and relative intakes of fescue at four different times of the year are presented in table 30. It was assumed that voluntary intake of alfalfa hay would be similar between trials, with variation due to weather and sheep. Using alfalfa hay as a reference feed has also been used successfully by Reid and Jung (1965b) in comparing voluntary intakes of first and second cut fescue hay.

In the present study, variation in the voluntary intake of alfalfa reference hay was recorded at different times (table 30). Fescue forage dry matter intakes relative to the voluntary intake of alfalfa hay were statistically analyzed.

The daily intake of fescue, expressed as grams per unit of metabolic size was lower than that of alfalfa hay for the forage harvested at all four times. The relative voluntary dry matter intake

TABLE 29. COMPOSITION OF ALFALFA HAY USED AS A REFERENCE FEED

Component	Alfalfa hay
Dry matter, %	94.3
Composition of dry matter, %	
Crude protein	17.4
Crude fiber	31.4
Ether extract	1.3
Nitrogen-free extract	38.8
Ash	11.1
Total nonstructural carbohydrates	5.4
Cell walls	54.6
Acid detergent fiber	41.2
Cellulose	29.7
Hemicellulose	13.4
Lignin	9.7
Residual ash	1.8

TABLE 30. VOLUNTARY DRY MATTER INTAKE FOR ALFALFA REFERENCE HAY AND FESCUE FORAGE HARVESTED AT FOUR DIFFERENT TIMES

Harvest time	Daily intake		Relative intake of fescue forage[a]
	Fescue	Alfalfa	
	- - - - - - - - $g/W_{kg}^{.75}$ - - - - - - - -		
May, 1977	76.6	121.3	63.3[b]
July, 1977	82.2	113.5	72.1[b]
November, 1977	57.9	68.4	87.7[c]
February, 1978	50.2	94.1	53.9[d]

[a]Expressed as a percent of alfalfa hay intake.
[b,c,d]Means in the same column with different superscript letters are different ($P<.05$).

of November harvested fescue forage was higher (P<.05) than forage harvested in May or July (87.7 vs. 63.3 and 72.1%, respectively). Intake was lowest (P<.05) for fescue harvested in February. Intake of July harvested fescue tended to be higher than that of the May harvested forage. Hemicellulose in fescue, which has been implicated as an antipalatability factor (Van Soest, 1976), was higher in May than in July (29.6 vs. 25.0%, respectively). Hemicellulose was lowest for November harvested fescue, which was consumed in the largest amounts, and highest in February harvested fescue forage, which was consumed in the lowest amounts. Reid and Jung (1965b) reported voluntary intakes of fescue hay were similar between first and second hay cuttings when fed to cattle. Baker et al. (1965) reported fescue forage to be a more palatable feed for grazing cattle than orchardgrass in early spring but not for summer regrowth. They speculated that fescue was preferably grazed in spring because of its earlier growth in spring and quicker recovery after defoliation.

The low voluntary intake of fescue in May could have resulted from the presence of stemmy material and seed heads. Although the fresh forage was put through a forage chopper prior to feeding, the stems present in May fescue were incompletely severed. Leaf material was cut to a uniform length by the forage chopper for all trials. The presence of stemmy material from the May fescue may affect palatability more adversely in sheep than cattle. May fescue was also undergoing the most rapid rate of lignification, compared to other times of the year (Sosulski et al., 1960).

May fescue forage was higher in nitrogen-free extract and total nonstructural carbohydrates and lower in acid detergent fiber and residual ash than July forage. The May harvested forage was also higher in dry matter digestibility. Reid et al. (1966) reported first cut hay was higher in dry matter digestibility than was second cut hay during the summer. Kroth et al. (1977) suggested cutting early head fescue for hay and refeeding the hay during the summer when the quality of fescue pasture is low.

Total nonstructural carbohydrate content is apparently an important factor present in forages in the summer as well as the winter. Disregarding palatability data from the May trial where fescue was in a different stage of growth from the other trials, the relationship between relative intake and nonstructural carbohydrate level is almost a linear one with higher levels of carbohydrates being positively related to voluntary intake. Percent intake and total nonstructural carbohydrates were 87.7 and 15.9, 72.1 and 9.9, and 53.9 and 5.5 for November, July and February, respectively.

The loss of nonstructural carbohydrates during the winter may be a critical problem. Soluble carbohydrates have been positively correlated to voluntary dry matter intake (Bland and Dent, 1962, and Reid et al., 1966). Maintaining higher nonstructural carbohydrate levels during the winter presents a possibility of counteracting the detrimental effects of winter burn on the palatability and quality of stockpiled fescue. Olien (1967) suggested plants may inhibit ice formation and the formation and the concomitant rupturing of the plant cell by the formation of complex carbohydrate polymers from the nonstructural carbohydrate component. Liberal fertilization with potassium has been advocated by Beard (1973) for stockpiling forages because of the role potassium plays in the metabolism and translocation of sugars in the plant tissue. Balasko (1977) also reported nitrogen fertilization increased total nonstructural carbohydrate content of stockpiled fescue. Using 70 to 100 kg of nitrogen per hectare for stockpiling forages should be more closely evaluated. These fertilization rates are primarily based on agronomic and economic considerations with little attention given to the interactions of nitrogen and potassium on total nonstructural carbohydrate content and their effects on palatability of the forage, especially late in the winter grazing season.

A second major factor influencing voluntary intake in this study appeared to be cell wall contents. Examination of the relative intake data and nutrient component data reveals a negative relationship between voluntary intake and percent cell walls. Relative intakes and cell wall contents were 87.7 and 59.8%, 72.1 and 63.3%, 63.3 and 65.6%, and 53.9 and 72.6% for November, July-August, May and February-March, respectively. It appears that high fiber levels in fescue restricted voluntary intake. Van Soest (1965b) reported fiber levels above 50 to 60% limited voluntary intake. Campling (1964) reported the fiber mass present in the rumen of animals fed a high roughage ration restricts intake due to physiological fill.

Relative Digestible Intake of Fescue. Table 31 shows the relative digestible dry matter intake of fescue forage harvested in May, July, November and February. These data were calculated using the voluntary intakes of fescue and alfalfa reference hay and the *in vivo* digestibility of these values. Relative digestible dry matter intake was similar for sheep fed May and July fescue. Highest values were for sheep fed November fescue. Stockpiling fescue maximizes palatability, quality and yield and appears to be an excellent method of managing fescue. This extension of the grazing season may greatly reduce feed costs to the farmer for maintaining cattle during the winter. Stockpiled February fescue is of much lower quality, showing the detrimental effects of cold weather on forage quality. The management of fescue pastures should include stockpiling the forage for winter grazing. Fescue has been shown to be a superior forage for stockpiling compared to orchardgrass (Archer and Decker, 1977a), bluegrass (Taylor and Templeton, 1976), or reed canarygrass (Bryan *et al*., 1970). Fescue accumulates high levels of total nonstructural carbohydrates during the fall (Brown *et al*., 1963) which tends to increase quality and palatability of the forage.

Owen *et al*. (1976) reported rate of eating, time spent eating and voluntary intake were lower for fescue than orchardgrass under spring and summer climatic conditions. These researchers suggested a chemical inhibitor or an unacceptable taste regulates the intake of fescue. Cattle grazing fescue in the summer do not gain as rapidly as compared to cattle on orchardgrass or bluegrass pastures (Blaser *et al*., 1956,

TABLE 31. VOLUNTARY DIGESTIBLE DRY MATTER INTAKE OF FESCUE FORAGE AND REFERENCE ALFALFA HAY

Harvest time of fescue	Daily intake[a]		Relative intake of fescue forage[b]
	Fescue	Alfalfa	
	- - - - - - - $g/Wkg^{.75}$ - - - - - - -		
May, 1977	51.7	70.4	73.4
July, 1977	47.2	65.9	71.6
November, 1977	36.6	39.7	92.2
February, 1978	21.4	54.6	39.2

[a]Calculated from data of palatability and in vivo digestion trials with fescue forage.
[b]Expressed as percent of alfalfa hay intake.

1960). Certainly, the management of fescue should include minimum grazing of the forage in the late spring and summer and removing the excess growth as hay. Stockpiling the forage for winter grazing maximizes digestible intake of the forage and would make an excellent forage source for high producing animals, such as fattening beef steers. The decline in quality during the winter suggests stockpiled fescue should be completely grazed down early in the winter by animals with high nutrient requirements. A high quality hay could be fed later in the winter. It would appear that the stockpiled forage in February may be high enough in quality for maintaining nonlactating beef cows. Stockpiled fescue could be made available for animals with low production needs the entire winter and greatly reduce hay feeding.

The management of fescue should be closely aligned with the requirements of the grazing animals. If fescue is the major pasture available for grazing cow-calf pairs, breeding and calving dates should coincide with the growth curves and quality output of the forage.

The major reason for the chemical evaluation of forages is to estimate quality and nutrient availability. It appears from this study that total nonstructural carbohydrate levels are the nutrient component most closely and positively related to voluntary intake and nutrient availability. Cell wall contents and hemicellulose appeared to be negatively related to palatability and nutrient digestibility. Kivimae (1960) reported the accuracy of estimating the digestibility of forages from the chemical component analysis varied greatly between plant species.

The data reported in this study aids further in classifying fescue forage not only in the spring and summer, but also during the winter.

SUMMARY

Research was conducted to study (a) yield and nutrient content of stockpiled fescue-red clover pastures during the winter, (b) seven forage-animal management systems for growing-finishing steers on forage with minimum grain feeding, and (c) palatability and nutrient availability of fescue forage at four times during the year.

Kentucky 31 tall fescue-red clover pastures were fertilized with 112 and 72 kg of nitrogen per hectare in early August and allowed to accumulate for winter grazing by growing-finishing steers. Animals were allowed access to stockpiled pastures on November 18, 1976 (day 0). Reference plots at Glade Spring were sampled at day 0, 25, 99, 125 and 140. Forage plots at Middleburg were sampled more often. Total non-structural carbohydrates and *in vitro* dry matter digestibility decreased ($P < .05$) and cell walls, acid detergent fiber, hemicellulose and lignin increased ($P < .05$) during the winter. *In vitro* digestibility data indicated red clover quality decreased more rapidly than fescue.

Forage-animal management systems were replicated at Glade Spring and Middleburg, Virginia. Weanling calf systems included top grazers with 0 (1) and .5% grain (2), whole plant grazers with 0 (3) and .5% grain increased to 1.0% in April (4). Yearling steer systems included whole plant grazers with .5% grain increased to 1.0% in April (5), top grazer with 0% grain (6) and whole plant grazers with 1.0% grain (7).

Average daily gains were higher in the winter at Middleburg (.75 *vs*. .52 kg) than Glade Spring. Steer gains were higher during sequence grazing in the summer at Glade Spring (.93 *vs*. .78 kg) than Middleburg.

Yearling steers gained at a faster rate during the growing-finishing period. Both top grazing and grain supplementation increased rates of gain for weanling calves. Yearling steer gains increased with grain supplement. Animals in all systems had slaughter grades of average to high good except yearling steers top grazing with no grain (high standard).

Four palatability trials were conducted with fescue forage beginning May 7, 1977, July 21, 1977, November 3, 1977 and February 12, 1978. Two metabolism trials were conducted using fescue forage harvested and dried at the midpoint of each palatability trial. Alfalfa hay from a common source was used as a reference forage for palatability and metabolism trials. Dry matter, organic matter and crude protein digestibilities were higher in May than July ($P < .05$). Values for November forage were intermediate between May and July. Digestibilities were lowest for March forage ($P < .05$). Fescue intake, expressed as a percent of the alfalfa reference feed, was 63.3, 72.1, 87.7 and 53.9 for the respective months. Relative intake was highest for November ($P < .05$) and lowest for February ($P < .05$). Nitrogen retention, expressed as grams per day, was lowest ($P < .05$) for February fescue. Stockpiling fescue maximized quality and palatability in November, but the forage severely deteriorated by February.

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THE PALATABILITY AND NUTRIENT VALUE OF
TALL FESCUE (*FESTUCA ARUNDINACEA* SCHREB.)
FORAGE AND EVALUATION OF SEVEN SYSTEMS
OF FORAGE FINISHING BEEF STEERS

by

Clyde Pattison Bagley

(ABSTRACT)

Research was conducted to study (a) yield and nutrient content of stockpiled fescue-red clover pastures during the winter, (b) seven forage-animal management systems for growing-finishing steers on forage with minimum grain feeding, and (c) palatability and nutrient availability of fescue forage at four different times during the year.

Kentucky 31 tall fescue(*Festuca arundinacea* Schreb.)-red clover (*Trifolium pratense* L.) pastures were fertilized with 112 and 72 kg of nitrogen per hectare in early August and allowed to accumulate for winter grazing by growing-finishing steers. Animals were allowed access to stockpiled pastures on November 18, 1976 (day 0). Reference plots at Glade Spring were sampled at day 0, 25, 99, 125 and 140. Forage plots at Middleburg were sampled more often. Total nonstructural carbohydrates and *in vitro* dry matter digestibility decreased ($P<.05$) and cell walls, acid detergent fiber, hemicellulose and lignin increased ($P<.05$) during the winter. *In vitro* digestibility data indicated red clover quality decreased more rapidly than fescue.

Forage-animal management systems were replicated at Glade Spring and Middleburg, Virginia. Weanling calf systems included top grazers

with 0 (1) and .5% (2), whole plant grazers with 0 (3) and .5% grain increased to 1.0% in April (4). Yearling steer systems included whole plant grazers with .5% grain increased to 1.0% in April (5), top grazers with 0% grain (6) and whole plant grazers with 1.0% grain (7).

Average daily gains were higher in the winter at Middleburg (.75 vs. .52 kg) than Glade Spring. Steer gains were higher during sequence grazing of fescue-red clover, bluegrass(Poa pratensis L.)-white clover(Trifolium repens L.) and orchardgrass(Dactylis glomerata L.)-alfalfa(Medicago sativa L.) in the summer at Glade Spring (.93 vs. .78 kg) than Middleburg. Yearling steers gained at a faster rate during the growing-finishing period. Both top grazing and grain supplementation increased rates of gain for weanling calves. Yearling steers gains increased with grain supplement. Animals in all systems had slaughter grades of average to high good except yearling steers top grazing with no grain (high standard).

Four palatability trials were conducted with fescue forage beginning May 7, 1977, July 21, 1977, November 3, 1977 and February 12, 1978. Two metabolism trials were conducted using fescue forage harvested and dried at the midpoint of each palatability trial. Alfalfa hay from a common source was used as a reference forage for palatability and metabolism trials. Dry matter, organic matter and crude protein digestibilities were higher in May than July ($P<.05$). Values for November forage were intermediate between May and July. Digestibilities were lowest for March forage ($P<.05$). Fescue intake, expressed as a percent of the alfalfa reference feed, was 63.3, 72.1, 87.7 and 53.9 for the respective months. Relative intake was highest for November ($P<.05$) and lowest for February ($P<.05$). Nitrogen retention, expressed as grams per day, was lowest ($P<.05$) for February fescue. Stockpiling fescue maximized quality and palatability in November, but the forage severely deteriorated by February.